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CONSTRUCTION OF A FOUR-SIDED OTTER TRAWL NET ADAPTED TO PHILIPPINE CONDITIONS

By SANTOS B. RASALAN and CIPRIANO C. MENGUITO
Of the Bureau of Fisheries, Manila

FOUR TEXT FIGURES

The four-sided otter trawl net (fig. 1, C) which is a modification of the Pacific-type net was introduced in the Philippines during the latter part of 1947 (Warfel and Manacop, 1950). Since then this net has been widely adopted by local otter trawl operators, especially those of Negros, Iloilo, Samar, and Pangasinan. It has a decided advantage over two other types introduced almost at the same time, the *mestizo* and the *Florida* otter trawl nets (fig. 1, A and B) in that it has a wider mouth opening and about five times longer wings than the Florida Type and needs less netting in construction than the mestizo type. Thus it is claimed to be more effective in catching fish and to last longer in operation than any of the other two types of trawl nets.

The present paper describes in detail the construction of a four-sided otter trawl net having 57 feet headrope which may be divided into preparation of the nettings, shaping of the parts, joining the parts together and hanging the net (fig. 1).

PREPARATION OF THE NETTINGS

The four-sided trawl net (fig. 1, C) consists of two wings two-side bellies (SB_L and SB_R); upper and lower wedges or corners (UWd and LWd); intermediate bag (IB); cod-end (CE); and the funnel (FL). Other parts which are needed to strengthen it are the headrope and footrope, which are both made of abaca, and the rib lines of either cotton or abaca.

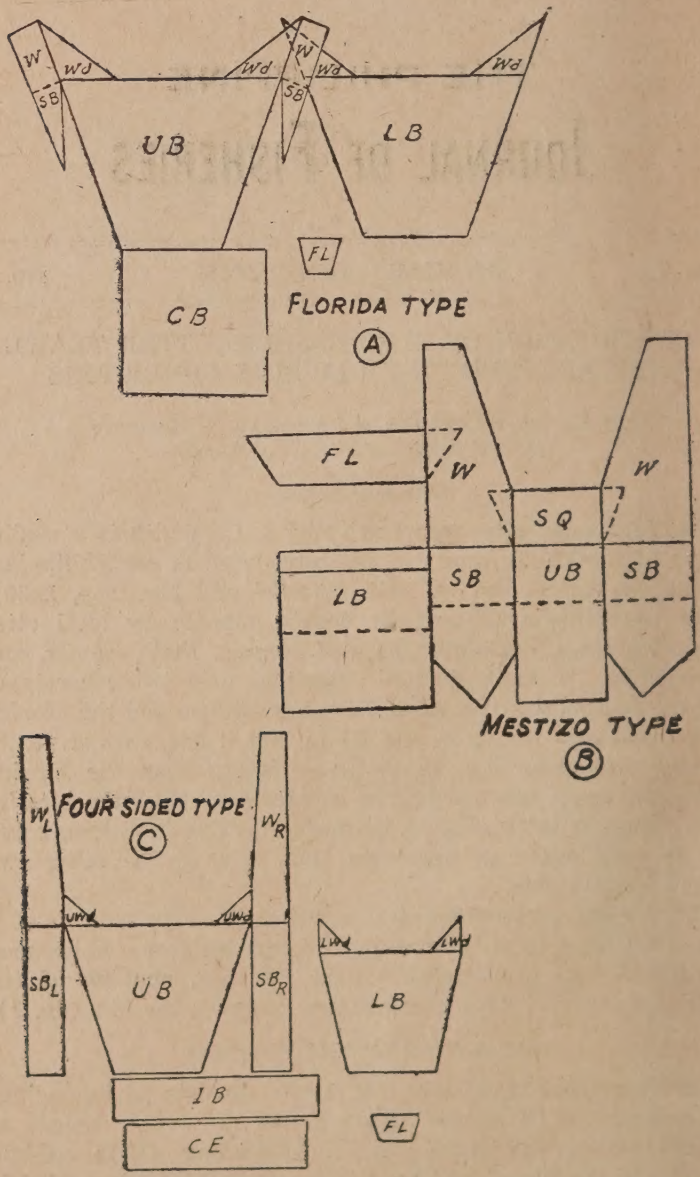

FIG. 1. Structural plans of three types of trawl nets used in the Philippines: A, Florida Type; B, Mestizo Type; C, Four Sided type. (UB, upper belly; LB, lower belly; W, wing Wd, Wedge; SB, side belly; CE, cod-end; FL, funnel; SQ, square or tenju; IB, Intermediate bag.)

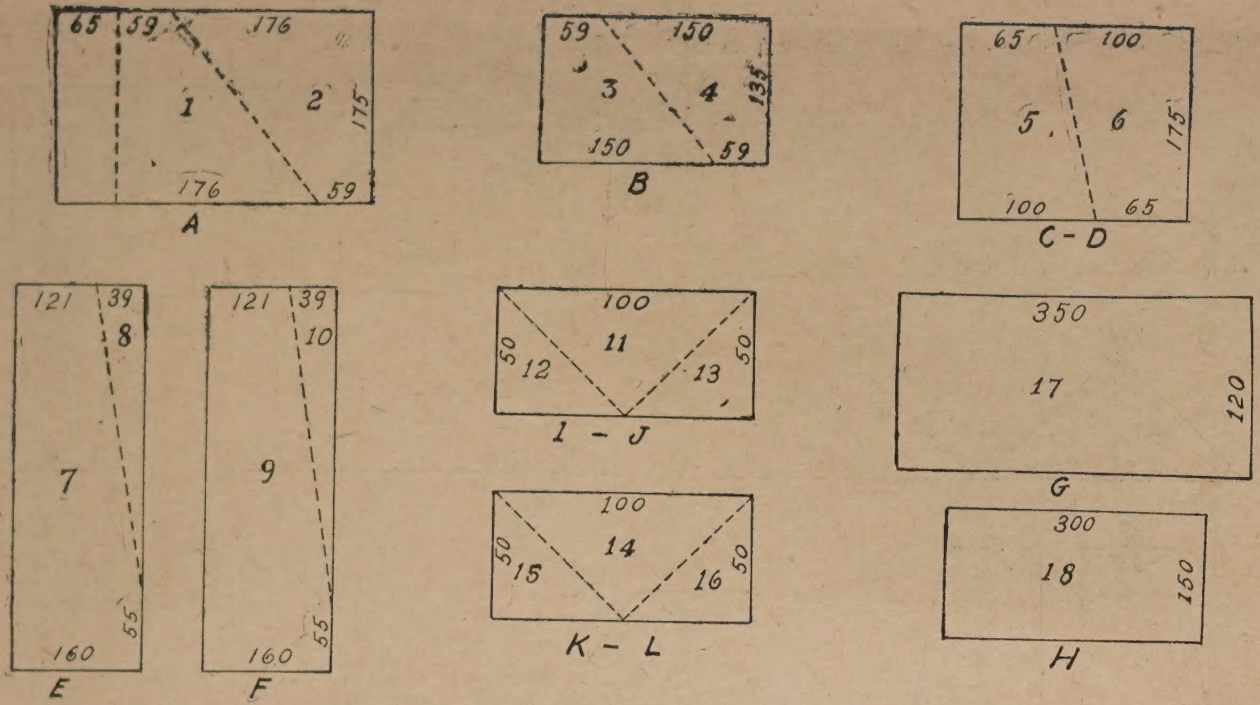

FIG. 2. Illustration of the method of cutting the different parts or sections of the net: A, upper belly; B, lower belly; C & D, side belly; E & F, wing; G. Intermediate bag; H, cod-end or bag; I, J, K, and L. wedges or corners.

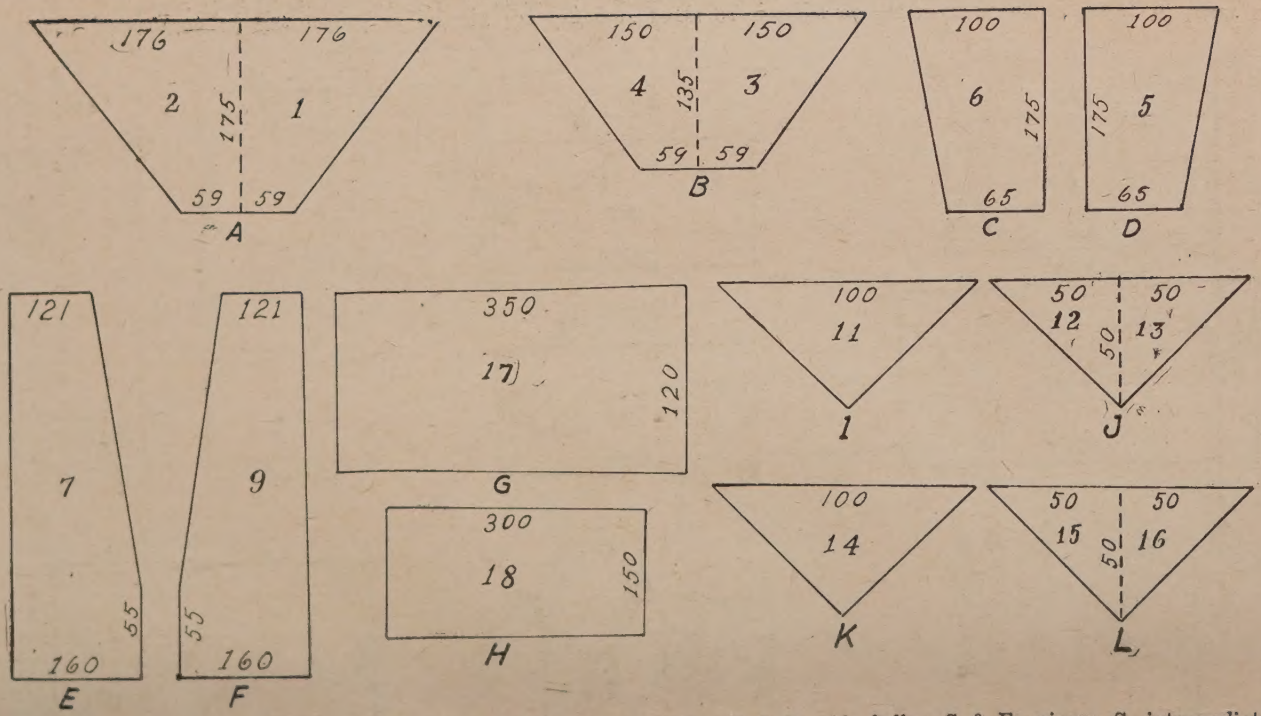

FIG. 3. Individual sections of the net: A, upper belly; B, lower belly; C & D, side belly; C & F, wings; S, intermediate bag; H, Cod-end or bag; and I, J, K and L, welges or corners.

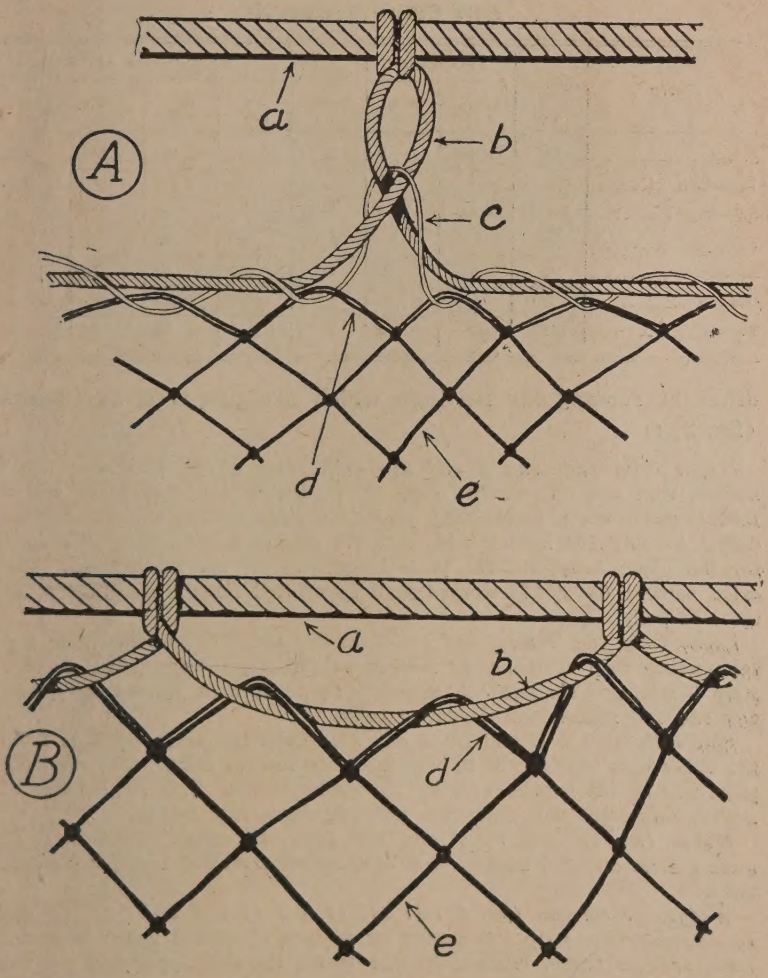

FIG. 4. Two ways of hanging on otter trawl net: *a*, footrope or headrope; *b*, hanging line or staple; *c*, lacing; *d*, selvage; *e*, net proper.

Nettings are sold in the market in bales, each 100 to 200 meshes wide and 100 meters long. It is, therefore, sometimes necessary to join one or two pieces, cut crosswise, then shaped according to the parts of the net by the bar-knot method.

The following shows the specifications of the different parts, while Figure 2 indicates the methods of cutting or shaping the

NET SPECIFICATION

Parts	Symbol	Materials		Mesh in inches	No. of meshes			Number of pieces
		Kind	Size		1st row	2nd row	Vert. row	
Wings	EF	Cotton	9	2	121	160	250	2
Upper belly	A	—do—	9	1-3/4	352	118	175	1
Side belly	C&D	—do—	9	1-3/4	100	65	175	2
Lower belly	B	—do—	9	1-3/4	300	118	135	1
Intermediate	G	—do—	12	1-3/4	350	350	120	1
Cod end	H	—do—	15	1	300	300	150	1
Wedges	IJKL	—do—	9	2	1	50	50	4

different rectangular nettings which are prepared as follows (fig. 2):

Upper belly (*fig. 2A: 1 and 2*).—Join three strips of nettings, 100 meshes wide and 175 meshes deep of 1¾ inches stretched mesh and 9 thread, producing a rectangular piece, 300 meshes wide and 175 meshes deep. As only 234 meshes wide and 175 meshes deep netting is needed for the upper belly, cut the piece lengthwise on the 235th mesh. The extra netting, 65 × 175 meshes shall be utilized for the construction of the side belly.

Lower belly (*fig. 2 B: 3 and 4*).—Join two strips 100 meshes wide and 135 meshes deep of the same netting as the upper belly. Add another strip 9 meshes wide and 135 meshes deep to form a rectangular piece, 209 and 135 meshes for the lower belly.

Side belly (*fig. 2 C and D: 5 and 6*).—Take the extra nettings from the upper belly and join it to a strip of 100 meshes down. The resulting piece will be 165 meshes wide by 175 meshes down. This single piece of netting when cut will cover the left and right side bellies.

Wings (*fig. 2E and F: 7 and 9*).—Join two strips of nettings, 80 meshes wide and 250 meshes deep of 2 inches stretched mesh, #9 cotton twine.

Wedges or corners (*fig. 2 I-J: 11, 12 and 13 and K-L: 14, 15 and 16*.—Prepare one strip 100 meshes by 50 meshes with 2 inches stretched mesh and #9 twine. This strip will do for the two upper and the two lower wedges.

Intermediate bag (*fig. 2G: 17*).—Join three 100 meshes wide and one 50 meshes wide all 120 meshes deep nettings forming one rectangular piece 350 meshes wide and 120 meshes deep of 1¼" stretched mesh of #15 twine. The two sides are later joined to form a prepared intermediate bag.

Cod-end (*fig. 2H: 18*).—Join three strips of 100 meshes wide and 150 meshes deep of 1" mesh stretched #12 cotton seine twine. The two longitudinal sides are joined to form a ready-made cod-end or bag.

The intermediate bag and the cod-end do not need further cutting as they are formed in their original rectangular forms.

SHAPING OF THE PARTS

Parts of the net are cut from the prepared rectangular piece of nettings as follows (fig. 3):

Upper belly (*fig. 3A: 1 and 2*).—Take the netting intended for the upper belly and count 59 horizontal meshes from the left. At the 60th mesh, cut the upper two bars slanting towards the right. From there, apply the 4 bars and 1 knot cut as illustrated in fig. 2A. The resulting two pieces are again joined together along their vertical straight side with the wider side of one and shorter horizontal sides of the other so that a trapezoidal net is formed for the upper belly.

Lower belly (*fig. 3B: 4 and 3*).—The same procedure is followed for the lower belly as for the upper, since both are of the same shape, although with different dimensions. The resulting form after the cutting and joining are made is 300 meshes at the head and 118 meshes at the base.

Side bellies (*fig. 3C and D: 6 and 5*).—Fig. 2C–D shows the method of cutting the side bellies. Take the prepared netting for this part. After the 65th mesh from the left, cut the netting using the 2 knots and 1 bar count and slanting towards the right. One piece of the net thus cut is for the left side belly and the other for the right side belly.

Wings (*fig. 3E and F.*)—Two nettings (fig 2E and F) should be cut separately for left and right wings. Take one piece and count 54 meshes upward starting from the lower right-hand corner. From that mesh start the 2 knots and 1 bar-cut (fig. 2 B, E, and F), slanting towards the left until the net is thoroughly cut. Do the same with the other piece and use one for the left wing and the other for the right wing.

Wedges or corners (*fig. 3I, J. and L*).—Utilize net I–J and K–L in fig. 2 for the wedge corners. Cut out I–J from the upper left-hand then upper right-hand corner towards the center of the lower edge by cutting all bars. The two small pieces thus cut are later joined together to form one wedge and the remaining big piece is for the other wedge (fig. 3: I–J).

For the other two wedges, take the other piece (fig. 2: K and L) of netting and cut as above. Again join the small pieces together and the two similar shapes thus made will be for the remaining two more wedges (fig. 3: K–L).

HOW TO JOIN THE PIECES TOGETHER

As shown in fig. 3 there are twelve individual sections comprising the whole four-sided trawl net (A to L) which have been cut from prepared rectangular pieces as described in the preceding paragraphs. These sections are formed as follows: the upper belly (A) is formed by joining two pieces (1) and (2) in the illustration as previously cut; the lower belly (B) by joining (3) and (4); the wedges (I–J) and (K–L) by joining (12) and (13), and (15) and (16), respectively. The other parts or sections, namely, the wings (E) and (F); and

the side belly (C) and (D); the wedges (I) and (K); and the intermediate bag (G) and cod-end (H) are in their original forms.

Joining the different parts to form the whole net is the next step. Pieces A to L of Figure 3 are joined together to make up the main body of the trawl. The pieces are joined as shown in the structural plan (fig. 1) from the wings down to the last part, the cod-end or the bag. In joining the sections, knitting with a net needle is applied. Mesh to mesh joining is used in the following: upper belly to side belly; upper belly to upper wedges; lower belly to side belly; lower belly to lower wedges; and mesh-to-mesh with *bating* for wings to side belly; all parts of the lower belly to the intermediate bag; and intermediate bag to the cod-end or bag proper. In joining the wings to the side belly, the *bating* is done once for every five meshes of the side belly; for the belly to the intermediate bag, once for every 7 meshes of the intermediate bag. In simple terms the proportions are as follows: 5 meshes of the side belly to be joined with 4 meshes of the wings; 23 meshes of the formed belly with 22 meshes of the intermediate bag; and 7 meshes of the intermediate bag with 6 meshes of the cod-end.

"Bating" in this article is defined as the method of decreasing the number of meshes in a net or section of the net. It is important to "bate" regularly when making the otter trawl net to insure even stress in the net when it is in operation. This factor has a great bearing in the catching efficiency of the whole gear.

Selvaging.—Selvaging strips in otter trawl nets are usually made in order to strengthen the edges of the net, especially those in contact with the headrope, footrope and hanging lines. The selvage may be of several meshes deep only but they are made of slightly bigger twines than those of the net proper. They are commonly knitted to the net before the net is hung.

HANGING THE NET

Proper hanging of the net does not only contribute to the attainment of high efficiency in the operation of the gear but also imparts an even distribution of the strain to all its components during the operation. After the different parts or sections have been connected the main body of the trawl is ready for hanging to the footrope and headrope.

The ropes for headrope, footrope and rib lines are first stretched to avoid shrinking while in the process of hanging and to

minimize expansion when used. They may be stretched by pulling on the ground or on the surface of the water by tying the rope on a moving vessel.

The headrope and footrope are cut from abaca rope of 1¼ inches diameter, 83 feet and 90 feet long, respectively.

There are two ways of hanging the net to the headrope or footrope which will both work well. One is by attaching staples or separate hanging line to the headrope or footrope at equal intervals by clove hitches and attaching the net to the staples or hanging line by lacing with a #9 or #12 cotton seine (doubled) at regular stress, and the other by simply passing the hanging line through the meshes of the net to be hung, tying the same line to the headrope or footrope by clove hitches as hanging goes along (fig. 4A and B).

The second method is done by folding the headrope and marked at the center. Then tie it between two posts of similar supports, one on the center thus marked and the other at the tips. At equal intervals of 4 inches for the main belly of the net and 5 inches for the wings, mark the headrope with chalk or charcoal. After the rope is marked evenly, have the hanging line, cotton twine #72, prepared in a knitting needle ready while attaching the center of the net to the center of the headrope. Pass the knitting needle through the center of the net and make a clove hitch in the rope. Then with another needle twine, continue the hanging on both sides of the net with particular attention to having the same number of meshes entering in each side. At the wings, make the interval of the clove hitching of the hanging line slightly longer. Proceed hanging up to the tip of the wings.

The procedure for hanging the net to the footrope is the same as that for the headrope except that the footrope is made longer so that the alignment of the meshes is stretched a little in such a manner as to provide the necessary even stress on the net.

The footrope must be longer by at least 10 per cent. In this case the footrope must be 65 feet long and the headrope about 57 feet.

NET SIZE AND VESSEL POWER

In otter trawling the right proportion of the size of net to the power of the vessel is paramount importance in the success of the fishing operation. Not only is efficiency of the gear enhanced, but also economy in expenses is achieved due to the minimized and unnecessary engine breakdowns.

The 57-footer net described in this paper is ideal for a 40- or 50-footer boat with a 225 H.P. high-speed engine or an 80–100 H.P. medium speed diesel engine of any brand. A regular speed of two knots, or slightly more, can be attained, which is just ideal for Philippine conditions to cover a good amount of fishing ground and catch a substantial amount of demersal fishes and shrimps.

In this respect, it is recommended that nets be made to such a size which can be dragged at a speed of 2 knots at least, with engine power slightly over half of its full load to avoid unnecessary breakdown of the engine.

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ILLUSTRATIONS

TEXT FIGURES

FIG. 1. Structural plans of three types of trawls nets used in the Philippines: *A*, Florida type; *B*, Mestizo type; *C*, Four-sided type. (*UB*, upper belly; *LB*, lower belly; *W*, wing; *Wd*, wedge; *SB*, side belly; *CE*, cod-end; *FL*, funnel; *SQ;* square or tenju; *IB*, Intermediate bag.)

2. Illustration of the method of cutting the different parts or sections of the net: *A*, upper belly; *B*, lower belly; *C* & *D*, side belly *E* & *F*, wings; *G*, intermediate bag; *H*, cod-end or bag; *I*, *J*, *K*, and *L*, wedges or corners.

3. Individual sections of the net: *A*, upper belly; *B*, lower belly; *C* & *D*, side belly; *E* & *F*, wings; *G*, intermediate bag; *H*, cod-end or bag; and *I*, *J*, *K*, and *L*, wedges or corners.

4. Two ways of hanging on otter trawl net: *a*, footrope or headrope; *b*, hanging line or staple; *c*, lacing; *d*, selvage; *e*, net proper.

OCEANOGRAPHY OF LINGAYEN GULF

By Alfonso R. Sebastian[1], Manuel N. Llorca[2], and Vitaliano B. Encina[3]

EIGHTEEN TEXT FIGURES

INTRODUCTION

No previous work of somewhat extended nature has been done on the waters of Lingayen Gulf, although mention may be made of the investigations carried on in connection with a study of the marine fauna of the western part of the gulf by Domantay (1937).

The present work embodies the results of a one-year oceanographic survey in which a maximum of ten hydrographic stations was occupied at nearly corresponding dates for twelve successive months from August, 1953, to July, 1954.

The investigation follows a similar pattern reported for Manila Bay (Megia et al., 1953). The primary purpose was to collect physical and chemical data for determining seasonal changes in the oceanographic properties of the gulf.

Description of the region.—Lingayen Gulf is an almost semicircular incursion of the South China Sea on the west coast of Luzon island. An almost continuous chain of islands and rocks, mostly low, wooded and separated by shallow channels, fringes the gulf on the western side. A series of shoals extends nearly halfway across the entrance from Cape Bolinao. The shore around the head is low and sandy.

Southeast winds prevail for the greater part of the year. Southwest gales blow from 3 to 15 days from July to October. The typhoon (cyclone) season occurs from mid-September to the end of October.

Several rivers drain into the gulf; Dagupan River in the south is the largest. Fig. 1 shows the bottom topography.

Station plan.—Fig. 2 shows a layout of the stations occupied during each of the twelve cruises.

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[2] Fishery Technologist, Bureau of Fisheries, Manila.

[3] Analytical Chemist, Bureau of Fisheries, Manila.

MATERIALS AND METHODS

Equipment, materials and methods of investigation are essentially the same as those outlined by Megia and Sebastian (1952).

Boat.—The "M/V David Starr Jordan", a 30–ton 135–H.P. research vessel of the Bureau of Fisheries, was assigned exclusively for the work. It was the same ship employed in the Manila Bay survey.

Thermometers and water bottles.—Watanabe deep sea reversing thermometers were used. These consistently gave readings reliable to 0.02°C. Two-plug valve type Nansen bottles of liter capacity were used as water samplers.

Observations.—Serial observations were made for samples taken at 0, 2, 5, 10, 20, 30, 50 meters below the surface. At certain stations samples were taken down to 75, 100, 150, and 200 meters.

Analytical procedure.—Chlorinity determinations were made with the modified Oxner-Knudsen method, using a Knudsen bulb, burette, and 15-ml automatic tap pipette. Standardization was made against a secondary sea-water standard obtained from Woods Hole standard sea water. Chlorosities were converted to chlorinities by the Thompson conversion tables (Cl/1 at 20°C. to Cl(‰). Accuracy in these determinations is within 0.02 ‰.

Dissolved oxygen determinations were made with a modified Winkler titration method, using standard potassium iodate solution of 0.01 normality, sodium thiosulfate solution of 0.005 normality and 0.1 per cent (by weight) sodium furoate. Precision of the determination is about 0.02 ml/1 of sea-water.

Inorganic phosphates were determined by the method of Deniges. Synthetic sea-water of about 18 ‰ chlorinity was used. The accuracy of the determination is from 5 to 10 per cent.

TEMPERATURE

Surface temperature.—Fig. 3 shows the monthly distribution of surface temperature. The highest surface temperatures were observed during the months of May to August, with values about one degree more than those for the other months. The highest average monthly value was 30.81°C in June. Maximum temperature value was 31.49°C. at station 9 in May.

FIG. 1. Bathymetric map of Lingayen Gulf

The lowest temperatures were obtained during the winter months from December to February. The lowest monthly average value was obtained in December, 27.99°C. Minimum value was 27.17°C. at station 6 in February.

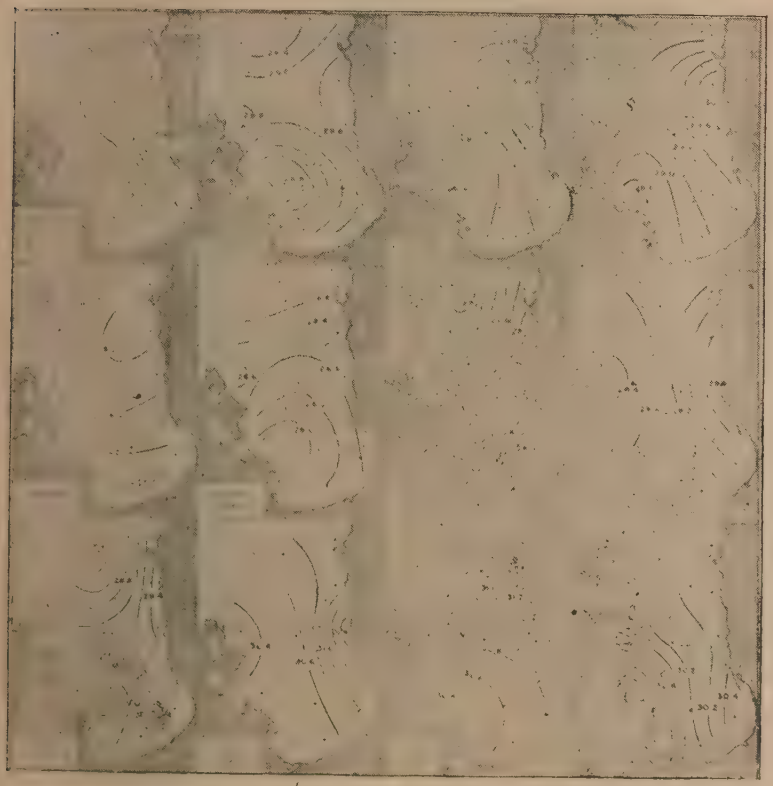

FIG. 3. Monthly distribution of surface temperature

The annual temperature range is relatively small, only 2.82°C., compared to 4.3°C. for Manila Bay.

Fig. 4 shows the close relationship between air temperature and surface water temperature throughout the survey.

The survey brings out the fact that the variation in the surface temperature of the gulf is seasonal in nature, as is that of Manila Bay.

Temperature at 20 meters.—Fig. 5 shows the monthly distribution of temperature at 20 meters. This follows closely the

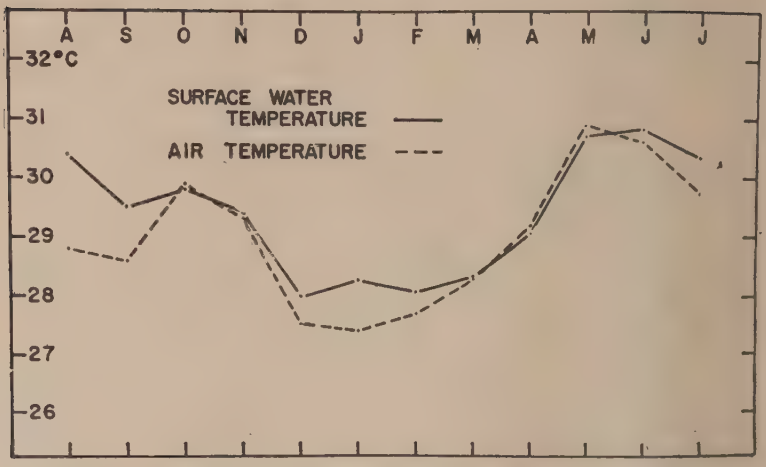

FIG. 4. Average surface water temperature and air temperature.

pattern of surface temperature distribution—highest from May to August and lowest during the winter months. The highest value of 30.73°C. was observed at station 10 in June while the lowest, 26.51°C., was at station 6 in February.

Temperature at other depths.—Fig. 6 shows the distribution of temperature in a vertical section across the gulf during the months of February and September, through stations 3, 4, 5 and 6. The average monthly temperature trend for all depths is also given in fig. 10.

CHLORINITY

Surface chlorinity.—A study of the monthly average surface chlorinity shows that the mean range is not large, from 15.89 $^0/_{00}$ in September to 18.47$^0/_{00}$ in May, or a mean annual range of 2.5 $^0/_{00}$. This is much lower than that for Manila Bay, 7.3 $^0/_{00}$, which is considered unusually large. The monthly distribution of surface chlorinity is shown in Fig. 7. The low values obtained and the close packing and decrease in value of the isochlors from the months of August to December show the effect of freshening due to heavy river discharge, especially during these rainy season months.

Chlorinity at 20 meters.—Fig. 8 shows the monthly distribution of chlorinity at 20 meters below the surface. An inward

FIG. 5. Monthly distribution of temperature at 20 meters.

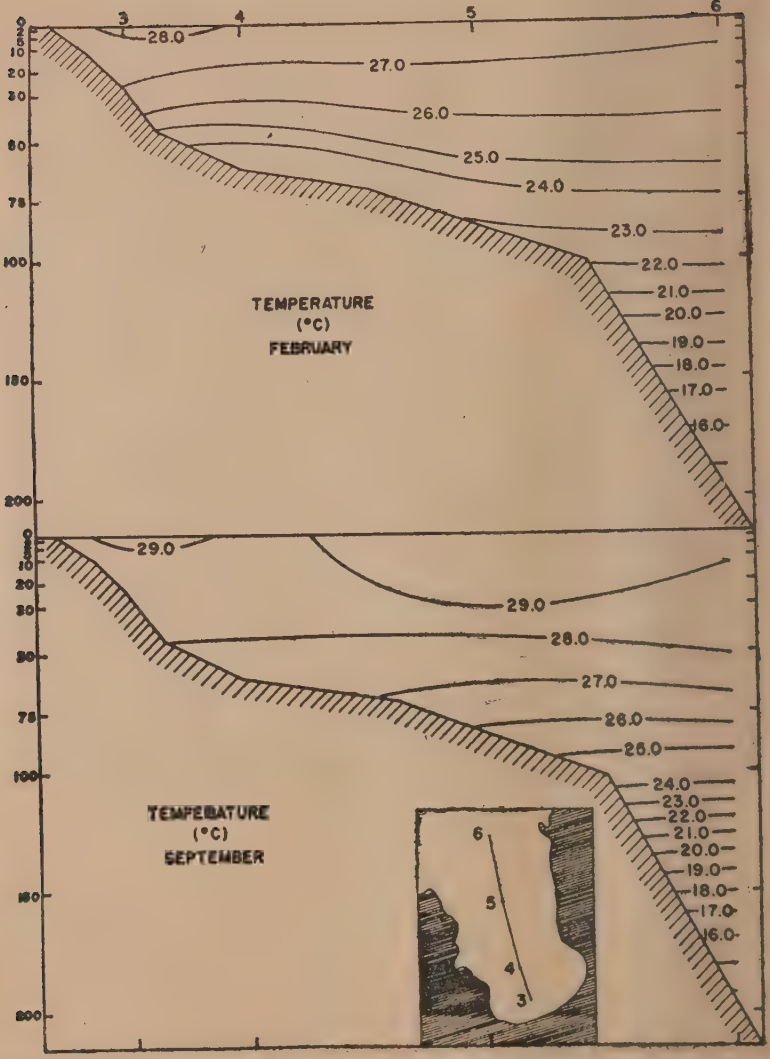

FIG. 6. Temperature distribution in a vertical section through stations 3, 4, 5 and 6 for February and September.

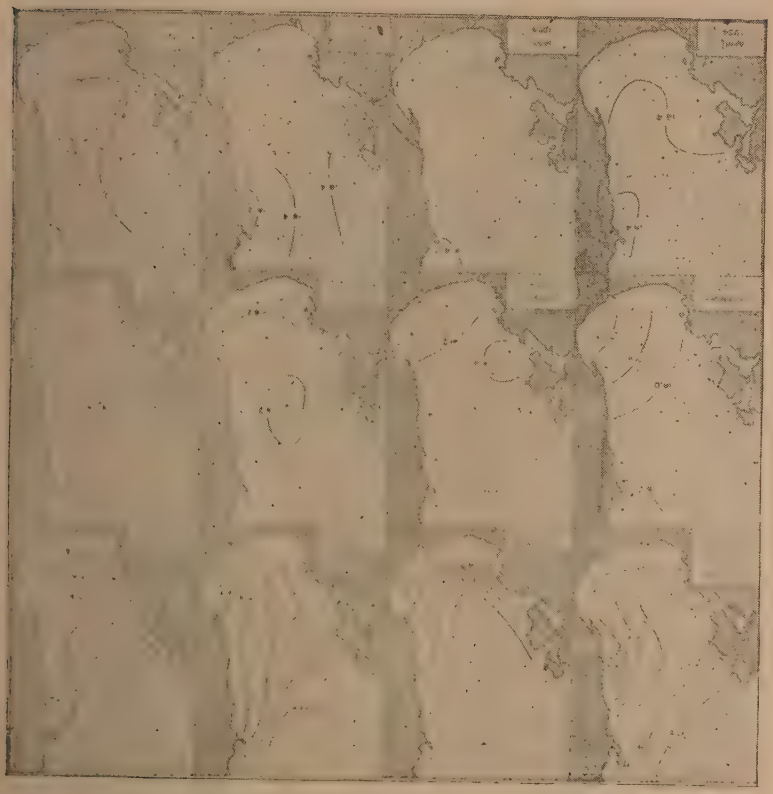

FIG. 7. Monthly distribution of surface chlorinity.

shifting of the high isochlors is evident for October to December. This may probably be explained by the fact that there is a reduction in the volume of river flow just after its peak in September.

FIG. 8. Monthly distribution of chlorinity at 20 meters.

Chlorinity at other depths.—Fig. 9 shows the distribution of chlorinity in a vertical section across the gulf during the months of February and September, through stations 3, 4, 5 and 6.

Fig. 10 shows the average monthly trends in temperature and chlorinity computed for all depths.

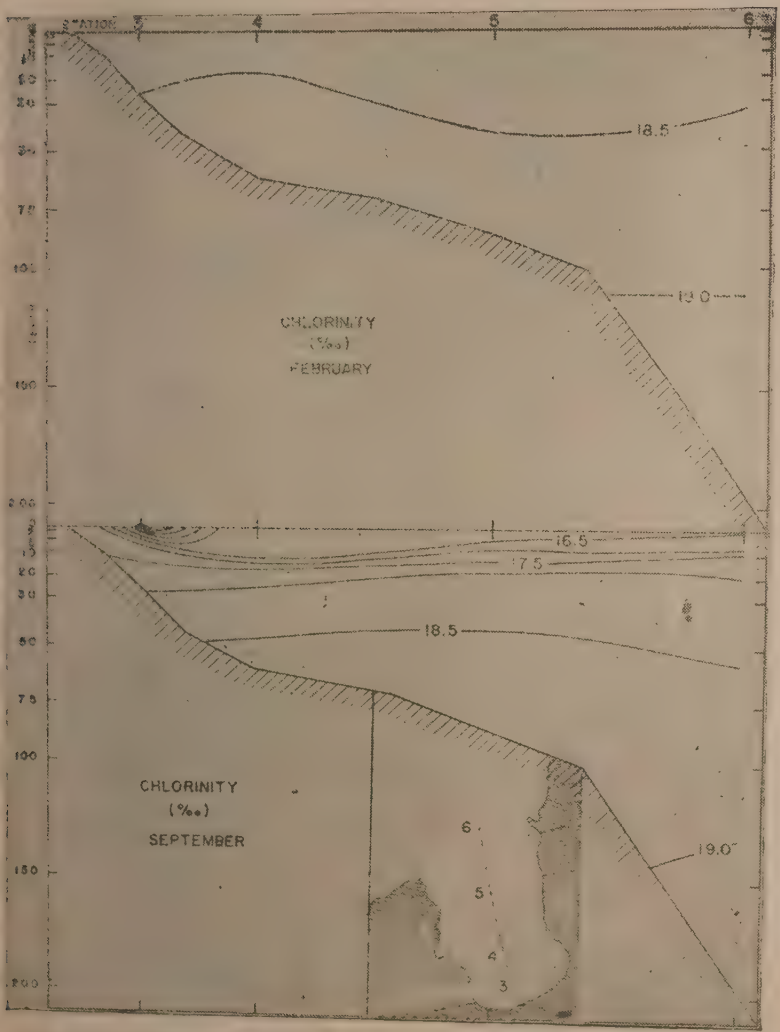

FIG. 9. Chlorinity distribution in a vertical section through stations 3, 4, 5 and 6 for February and September.

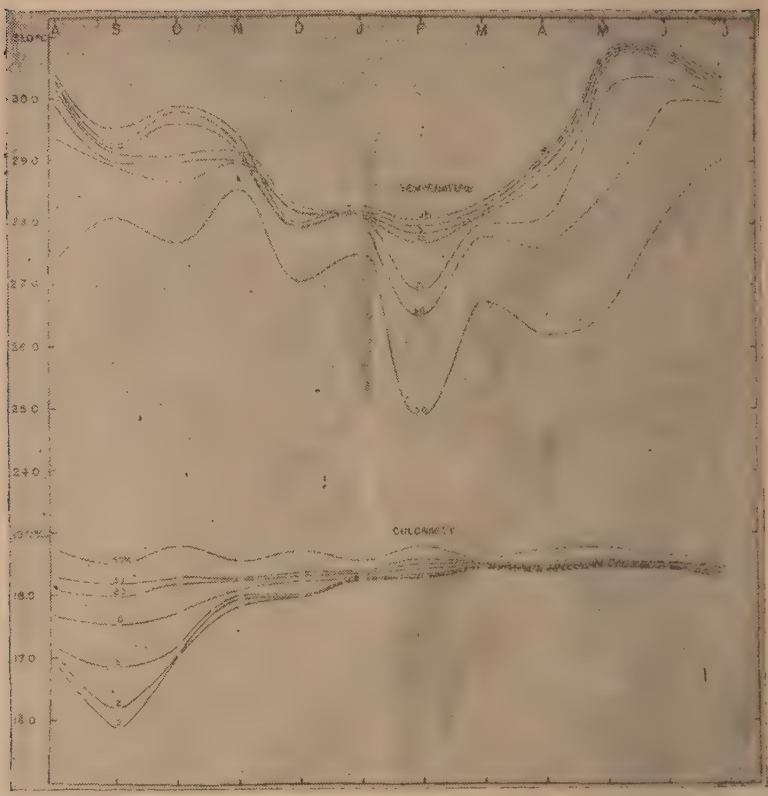

FIG. 10. Average monthly trends in chlorinity and temperature for all depths.

DISSOLVED OXYGEN

Figs. 11 and 12 show the monthly distribution of dissolved oxygen at the surface and at 20 meters. Values are expressed in mg-at/1. Maximum values were observed in February to May. The highest concentrations were not found close to the tributaries, and since this is about the time of little run-off, these high values may be due to biological activity.

Fig. 13 shows the distribution of dissolved oxygen in a vertical section across the gulf in February and September through stations 3, 4, 5 and 6.

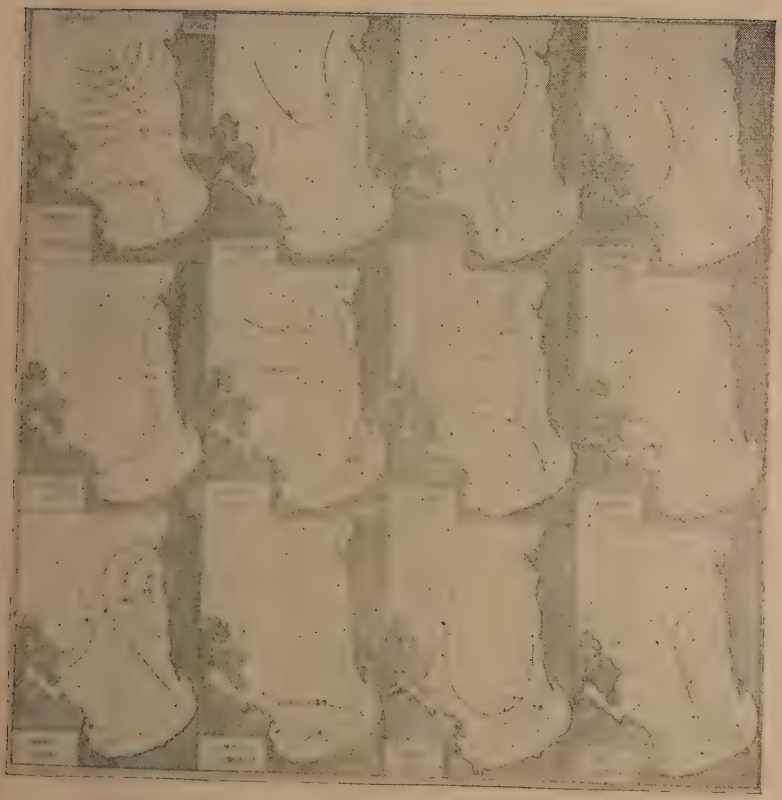

FIG. 11. Monthly distribution of dissolved oxygen at the surface.

FIG. 12. Monthly distribution of dissolved oxygen at 20 meters.

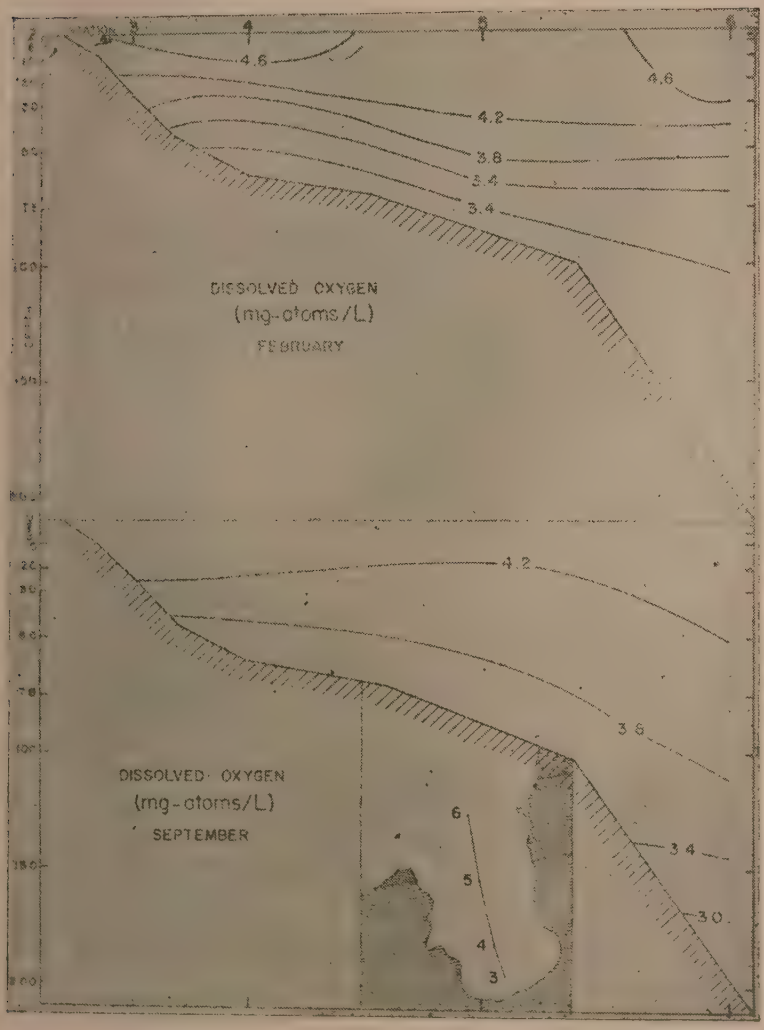

FIG. 13. Distribution of dissolved oxygen in a vertical section through stations 3, 4, 5 and 6 for February and September.

Fig. 14 shows the seasonal variation in oxygen saturation (per cent) and phosphate content from the surface to 75 meters at station 5.

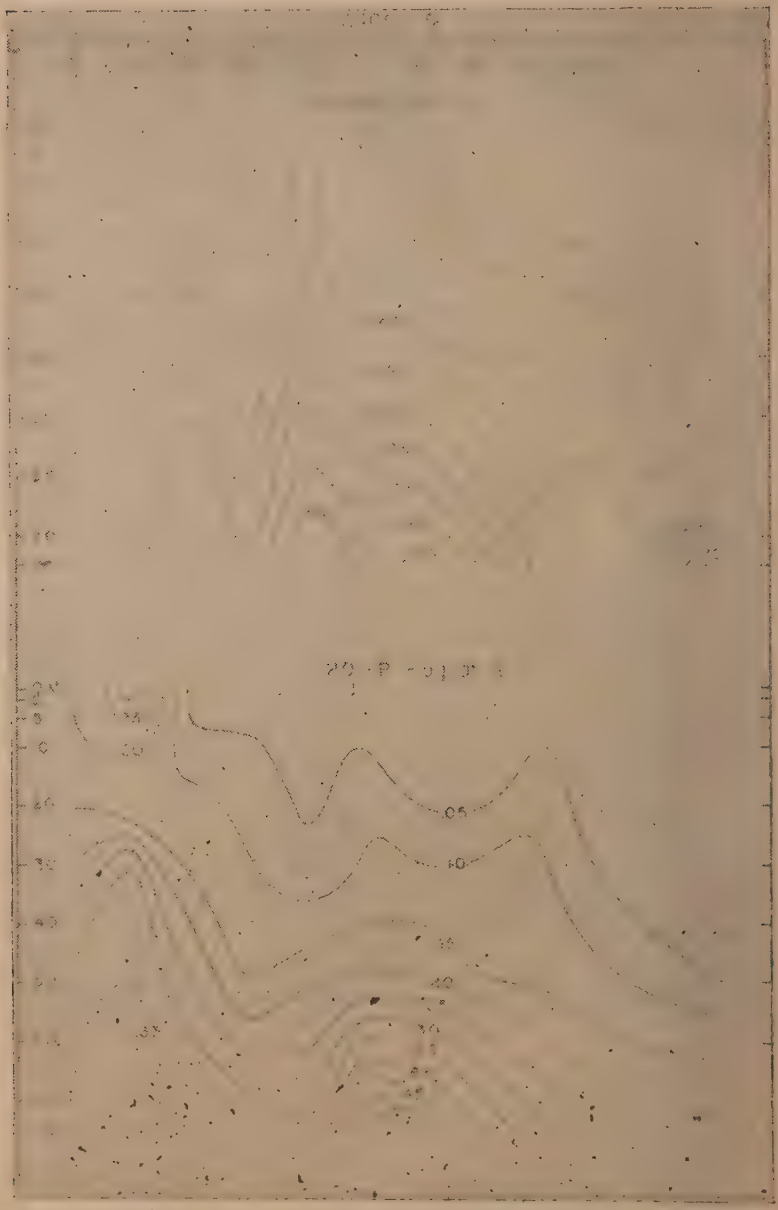

FIG. 14. Seasonal variation in oxygen saturation (per cent) and phosphate content from the surface to 75 meters at station 5.

INORGANIC PHOSPHATES

Figs. 15 and 16 show the monthly distribution of inorganic phosphates at the surface and at 20 meters. Only small variations exist from month to month and from place to place, but it is observed that low phosphate content exists at the surface from January to July and at 20 meters from April to July. Maximum values were obtained in August and September. This apparently brings out the direct association of phosphate abundance with fluctuations in river discharge.

FIG. 15. Monthly distribution of inorganic phosphates at the surface.

FIG. 16. Monthly distribution of inorganic phosphates at 20 meters.

Fig. 17 shows the distribution of phosphate—phosphorus in a vertical section across the gulf through stations 3, 4, 5 and 6 during the months of February and September.

Fig. 18 shows the seasonal variation in temperature, chlorinity, dissolved oxygen, and phosphate content of the surface layer (0–10 meters) and the bottom layer at station 4 during the entire period of investigation.

SUMMARY

1. Data are presented with figures, showing changes in temperature, chlorinity, and in the concentrations of dissolved oxygen and inorganic phosphates in the waters of Lingayen Gulf during twelve monthly cruises from August, 1953, to July, 1954.

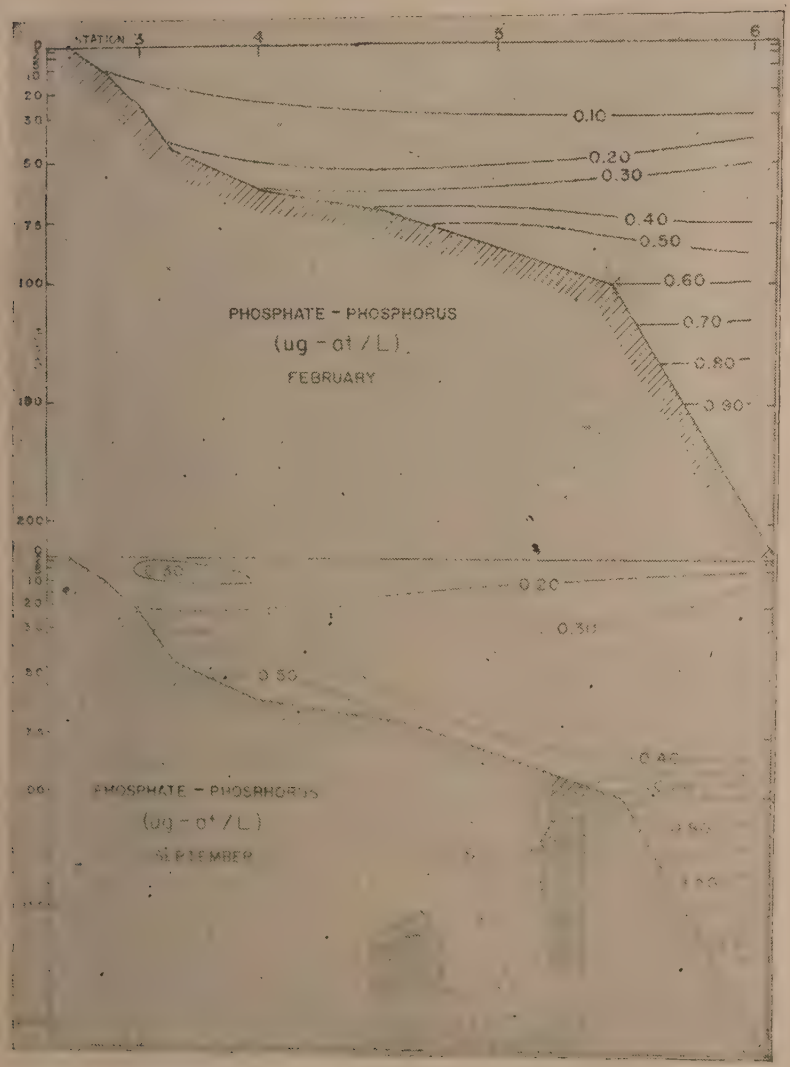

FIG. 17. Distribution of phosphate-phosphorus in a vertical section through stations 3, 4, 5 and 6 for February and September.

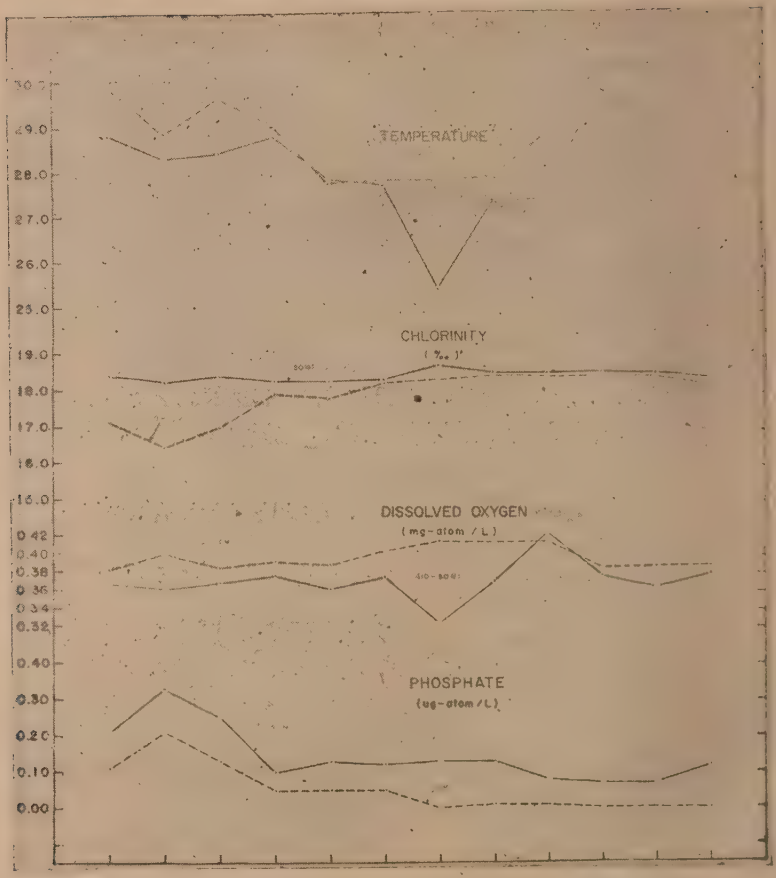

FIG. 18. Seasonal variation in temperature, chlorinity, dissolved oxygen and phosphate content of surface layer (0–10 meters) and bottom layer at station 4.

2. Variations in temperature distribution are seasonal. The highest surface temperatures occur from May to August, with values about one degree more than those for other months. The lowest values are observed during the winter months, December to February. The highest value obtained was 31.49°C. in May and the lowest was 27.17°C. in February.

3. The annual range in temperature is relatively small compared to that of Manila Bay.

4. The monthly average surface chlorinity varied from a minimum of 15.89‰ in September to a maximum of 18.47‰

in May or a range of 2.58°/00, much lower than that for Manila Bay, 7.3°/00, which is considered unusually large. The effect upon chlorinity of freshening due to heavy river discharge is shown.

5. Maximum values for dissolved oxygen were observed from February to May. The high concentrations were not found close to the tributaries, and since this is about the time of little run-off, these high values may be due to biological activity, not to river flow.

6. Maximum phosphate content was observed in August and September; minimum values, from January to July. This brings out the direct relationship of phosphate abundance to great river discharge.

7. The seasonal variation is shown of temperature, chlorinity, dissolved oxygen, and phosphate content at the surface layer and at the bottom layer at a selected station for the entire period of investigation.

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ILLUSTRATIONS

TEXT FIGURES

FIG. 1. Bathymetric map of Lingayen Gulf.
2. Layout of stations occupied during each cruise.
3. Monthly distribution of surface temperature.
4. Average surface water temperature and air temperature.
5. Monthly distribution of temperature at 20 meters.
6. Temperature distribution in a vertical section through stations 3, 4, 5 and 6 for February and September.
7. Monthly distribution of surface chlorinity.
8. Monthly distribution of chlorinity at 20 meters.
9. Chlorinity distribution in a vertical section through stations 3, 4, 5 and 6 for February and September.
10. Average monthly trends in chlorinity and temperature for all depths.
11. Monthly distribution of dissolved oxygen at the surface.
12. Monthly distribution of dissolved oxygen at 20 meters.
13. Distribution of dissolved oxygen in a vertical section through stations 3, 4, 5 and 6 for February and September.
14. Seasonal variation in oxygen saturation (per cent) and phosphate content from the surface to 75 meters at station 5.
15. Monthly distribution of inorganic phosphates at the surface.
16. Monthly distribution of inorganic phosphates at 20 meters.
17. Distribution of phosphate-phosphorus in a vertical section through stations 3, 4, 5 and 6 for February and September.
18. Seasonal variation in temperature, chlorinity, dissolved oxygen and phospate content of surface layer 0–10 meters and bottom layer at station 4.

EFFECTIVENESS OF SORBISTAT ON THE STORAGE AND KEEPING QUALITY OF DRIED FISHERY PRODUCTS

By Silvestre V. Bersamin, Natividad Mácalincag and Anselma S. Legaspi

Of the Division of Fisheries Research, Bureau of Fisheries

INTRODUCTION

One of the perennial problems that confront our fish processors is the growth of yeasts and molds on dried fish products, which results in the production of low-grade quality commodities. Our storage facilities, our marketing methods and climatic conditions are all conducive to mold growth. With this in view, experiments which would inhibit their growth have been performed in the Microbiological Laboratory of the Bureau of Fisheries.

This investigation aims to look for a way to inhibit or delay the development of yeasts and molds in dried fishery products, which ultimately would improve their keeping quality.

A ready answer to this problem is found in the use of sorbistat, a brand of sorbic acid, an effective, non-toxic and practical fungistatic agent for foods. It is unique among food additives, being a metabolizable food, added for protective purposes to another food.

What is sorbistat? Sorbistat is a brand of sorbic acid. It is an unsaturated fatty acid with six carbon atoms having a formula of CH_3–CH–CH–CH–CH–COOH which is metabolized into carbon dioxide and water when ingested by the body. The penetration of sorbistat solution in fish is superficial, hence, the amino acid content of the fish is not affected by the action of this agent.

Before sorbic acid was used as a fungistatic agent to foods, Deuel, H. J., et al. (1954), Smith, D. P., et al. (1954), and Stephens, M. R., et al. (1952), have demonstrated that it was harmless. Effectiveness of sorbic acid in inhibiting molds has been successfully used in the making of cakes, cheese and in smoked fishery products by Melnick, D., et al. (1956), Boyd,

J. W., et al. (1953), and Geminder, J. J. (1959). The latter states that potassium and sodium sorbate are used because their water solubility is superior to that of sorbic acid and they are approximately equal in antimycotic activity. On the acid surface of the fish, potassium or sodium sorbate is converted into active sorbic acid.

The main reasons of the U. S. Food and Drug Administration for the preferential use of sorbic acid over other fungistatic agents are its effectiveness in extending the shelf-life and the property of retaining natural flavor of treated foods.

Since the climatic condition of the Philippines is very different from that of the United States where the use of sorbic acid is highly acclaimed, experiments have been done in this laboratory to determine the effectivity of sorbistat in lengthening the shelf-life of dried fishery products under local conditions. Two experiments have been conducted; one, utilizing *Sardinella* species, and the other, *Decapterus* species, locally known as sardines and galongong, respectively.

EXPERIMENT I

Materials and Method.—The fish were washed in the round with tap water, soaked in concentrated brine for four hours, drained, and then sun-dried. The dried fish were divided into four batches, one batch was used as control, and the other three were treated with 0.1 per cent, 0.5 percent, and 1.0 per cent, sorbistat solutions, respectively. Each batch was weighed, then dipped for ten minutes in their respective solutions with the concentrations stated above. After this treatment, all the batches were dried to approximately the same as their weight before they were dipped in sorbistat solutions. Half of the samples in each batch was packed in cellophane bags, sealed and stored at room temperature. The other half was exposed to ordinary room temperature.

Discussion and results.—Table 1 shows the results of the experiment with *Sardinella* species. It was noted that the use of 1.0 per cent, solution produced very effective results. Even after five months storage they were negative for mold growth. The use of 0.5 per cent sorbistat was effective up to a limited period. The longevity of storage of the treated samples was increased by the use of cellophane bags. In this investigation, commercially prepared "pure" salt and ordinary solar salt were used. In the experimental batches utilizing pure and

TABLE 1.—*Showing the average of the experiments of each of the experimental batches including the control group.*

Kind of salt	Concentration of sorbistat solution	Condition of storage	Initial No. of days	Molding	Final No. of days	Molding
				Per cent		*Per cent*
Pure	Control *Per cent*	Exposed	17	11	31	92
		Sealed	35	10	55	25
	0.1	Exposed	19	11	33	88
		Sealed	92	25	104	44
	0.5	Exposed	28	11	48	55
		Sealed	(a)	(a)	(a)	
	1.0	Exposed	81	2.6	94	5.2
		Sealed	(a) *	(a)	(a)	100
Impure	Control *Per cent*	Exposed	17	52.75	26	
		Sealed	30	12.50	48	42
	0.1	Exposed	20	52.60	28	100
		Sealed	89	4	104	44
	0.5	Exposed	86	8	99	50
		Sealed	(a)	(a)	(a)	
	1.0	Exposed	90	3.3	104	6.6
		Sealed	(a)	(a)	(a)	

[2] (a) Means negative.

impure salt all the sealed samples treated with 0.5 per cent and 1.0 per cent sorbistat did not develop any mold growth up to the end of the experimental period, but in the exposed samples the concentration of 1.0 per cent sorbistat solution was more effective in arresting mold growth as shown in Table 1. The use of pure and impure salt did not show any significant difference in their effect on resisting mold growth. However, the use of pure salt is preferrable from the standpoint of yielding a better quality product.

Observation of results was stopped after five months. Usually dried fish in the local markets are disposed long before 5-month period is reached. The initial period was taken when the molds began to develop and the final period was determined when molds ceased to develop.

The molds identified in the investigation were *penicillium glaucum, Aspergillus glaucus,* and *Rhizopus nigricans.*

EXPERIMENT 2

Materials and method.—The fish were split, all internal organs removed and washed with tap water. The cleaned split fish were soaked in concentrated brine (23 Be) for 12 hours. The fish were divided into two batches. They were then taken from the brine solution and subjected to the refreshing method

or washing which consists of soaking the fish in tap water, the volume of which is equivalent to twice the weight of the fish. The refreshing method washes away the impurities of the solar salt used and decreases the degree of saltiness. In the control batch, no sorbistat was added to the refreshing water whereas in the other batch, a concentration of 0.5 per cent sorbistat was added. The length of washing in both batches was one hour. They were then drained thoroughly and dried under the sun. Half of the treated and untreated samples was sealed in cellophane bags. The rest were exposed. All the samples were stored at room temperature.

Results and discussion.—Table 2 shows the result of the experiment with *Decapterus* species.

TABLE 2.—*Showing result of experiment with Decapterus species.*

Control			With 0.5 per cent sorbistat solution		
No. of days	Condition of storage	Remarks	No. of days	Condition of storage	Remarks
16	Exposed	Samples became too dry, no chance for mold to develop.	16	Exposed	Samples became too dry, no chance for mold to develop.
16	Sealed	Negative	16	Sealed	Negative
25	Exposed	Samples discarded	25	Exposed	Samples discarded
25	Sealed	100 per cent moldy	25	Sealed	Negative
128	Exposed	Sample discarded	128	Exposed	Samples discarded
128	Sealed	100 per cent moldy	128	Sealed	Negative
12 mos	Exposed	Sample discarded	12 mos	Exposed	Samples discarded
12 mos	Sealed	100 per cent moldy	12 mos	Sealed	Negative

After 16 days of storage, all exposed samples with or without sorbistat became too dry to give a chance for molds to develop. The high degree of dehydration may be attributed to the hot weather at that time of the year. These samples were discarded. All the sealed samples with or without sorbistat retained their original dryness, and developed a reddish color. No molds developed.

After 25 days, all sealed samples without sorbistat were moldy. Sample refreshed in 0.5 per cent sorbistat solution for one hour did not develop any mold.

After 128 days the sealed samples with sorbistat became too dehydrated and did not develop any mold growth. They were considered unfit for human consumption.

To further determine the extent of effectivity of sorbistat as a fungistatic agent in this experiment, the sealed samples which developed molds after 25 days and those which did not develop mold were mixed together and stored at ordinary room

conditions. After a period of about eleven months, another visual examination was made. Those samples dipped in 0.5 per cent sorbistat solution did not develop any mold growth in spite of their close contact with the contaminants.

SUMMARY

Sorbistat, which is a brand of sorbic acid, was capable of preventing the growth of yeasts and molds among the common dried fishery products, such as the *Sardinella* and *Decapterus* species.

A concentration of 1.0 per cent solution used as a dip for 10 minutes prevented the growth of molds on dried fish in the round for more than five months. The effectivity was further increased when the treated fish were sealed in cellophane bags.

On the other hand, split fish, which were brined overnight and washed or refreshed in water mixed with 0.5 per cent solution for one hour before they were sun-dried, did not develop molds for about a period of one year.

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THE PHILIPPINE FISH MEASURING BOARD

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TWO TEXT FIGURES

The International Training Center on the Methodology and Techniques of Research on Mackerel (*Rastrelliger*) was held from 20 October to 28 November 1958 under the auspices of the Food and Agriculture Organization of the United Nations and the Government of Thailand at Bangkok. In collecting data for length composition study several measuring boards were used. One of the handicaps encountered in field work was the necessity of assigning at least two individual workers in the sampling process, one who reads and sounds off the length of fish and another who records the measurement. When time is limited, this method is likely to cause errors.

An attempt to get nearly accurate data with the least effort is submitted by one of the participants to the *Rastrelliger* Training Center for consideration as a standard equipment for measuring length of fish. A single worker can do the work of two individuals with a higher degree of accuracy in a shorter time.

This measuring board, the Philippine Fish Measuring Board, is designed to measure fish not exceeding 30 cm. A similar board for measuring longer fish can be constructed on the same principle.

DESCRIPTION

The measuring board has five parts, as follows:

(1) Main board—To this is attached a ruler, almost at center, with its right section calibrated to 0.5 centimeter. The board is 30.0 × 9.0 × 1.5 cm.

(2) Divider—This is the thin piece of board attached to the calibrated side of the main board. It protects the tally sheet from getting wet and dirty when measuring.

(3) Tally sheet board—This board, 30.0 × 10.0 × 1.5 cm. is hinged to the main board so that it can be folded backward. This makes the measuring board handy.

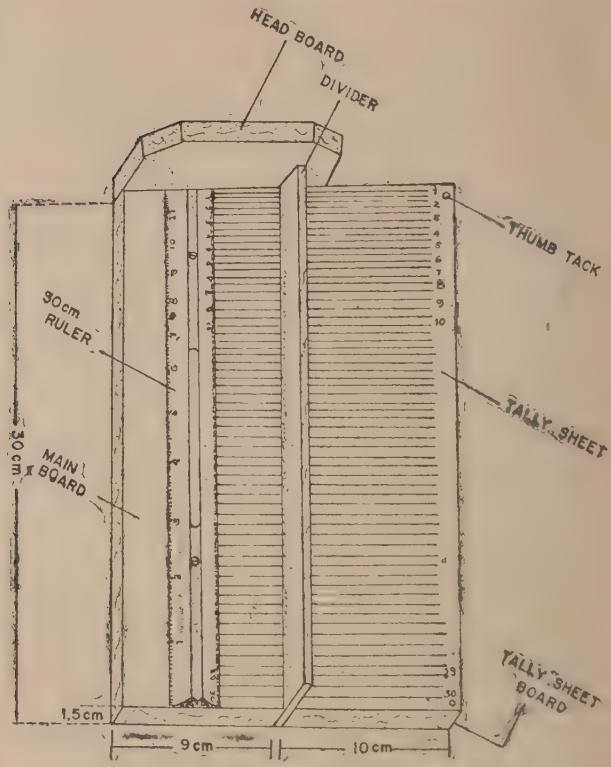

FIG. 1. Philippine Fish Measuring Board

(4) Tally sheet—The tally sheet is the same in size as the tally sheet board and ruled 0.5 centimeter apart. It is secured to the tally sheet board by thumb tacks at the four corners. The fish measured is tallied on the line indicating the length.

(5) Head board—The board is attached to the zero (0) end of the main board. It serves not only as a handle but as a fixed point for the anterior tip of the fish when measuring it.

WORKING PRINCIPLE

Unfold the measuring board, the backside down and head board forward. Place the tally sheet on the tally sheet board in such a manner that the lines of the tally sheet coincide with the calibrated lines of the main board. Secure the tally sheet with thumb tacks at the corners and number the right hand side of the sheet with the corresponding number of the centimeter length of the ruler. This makes the tally sheet a measuring unit in itself.

FIG. 2. Sample Tally Sheet

Place the fish with its lateral side on the calibrated section of the main board and the anterior tip close to the inner side of the handle or the zero (0) mark of the main board. The reading of the length of the fish in any manner desired by the worker is recorded on the tally sheet exactly on the corresponding space provided for. Measurements of 100 specimens can be done in less than 10 minutes with ease by a single worker.

Other data as date, place, name of species, etc. may be indicated on the right hand margin of the tally sheet.

ILLUSTRATIONS

TEXT FIGURES

FIG. 1. Philippine Fish Measuring Board.
2. Sample tally sheet.

45

SIZE, LENGTH AND DEPTH RELATIONSHIPS OF A MESH WHEN HUNG

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SEVEN TEXT FIGURES

The length and depth of a piece of netting after hanging it to a hanging line are determined by the number and size of its mesh. It is, therefore, reasonable to appreciate the value of a correct mesh measurement, the proper understanding of which is essential to the effectiveness of any fishing gear design.

Mesh, to a fisherman, is defined as one of the similar spaces or openings enclosed by weaving the thread into a net. Its size is determined by the length of the thread which encloses that space. This enclosure is made up of four equal legs or bars, each with a knot between them.

Mesh is conventionally measured in a stretched condition from the first to the end knot at their center points known as center measurement and/or inside of the knots called inside measurement. This is called stretched measure (fig. 1).

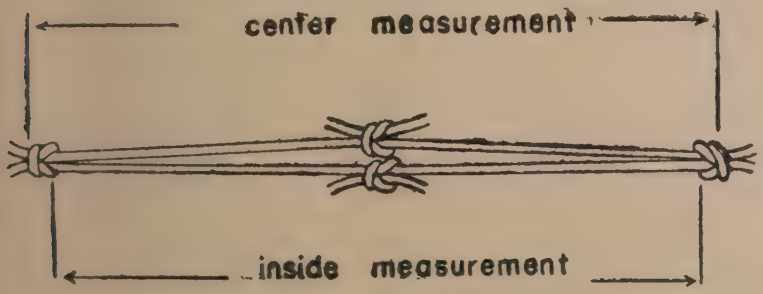


Fig. 1. Stretched measure

The inside measurement is appropriate only in fish conservation work where the inside dimension is considered in relation to the size of the fish for escape purposes, while the center measurement measures only the straight distance between the terminal knots and not the true mesh size.

In both methods, the true size of the mesh is inaccurately measured because of the presence of the center knots B which

makes the bars AB and BC not in one line as shown in fig. 2. This inaccurate measurement of the mesh size certainly would result in a faulty determination of the hanging length and depth of nettings.

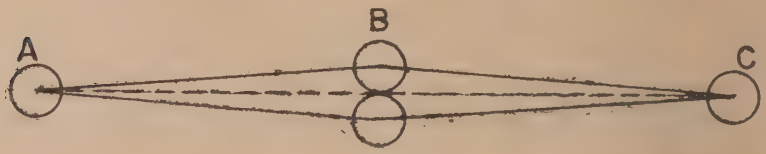


FIG. 2. Bar x 2 measurement,—solid line; stretched length—dotted line.

Usually, a stretched mesh is given a length of 100 per cent and a depth value of zero. Actually, however, depth is more than zero since knots have thickness. Thus, in fig. 3 the true

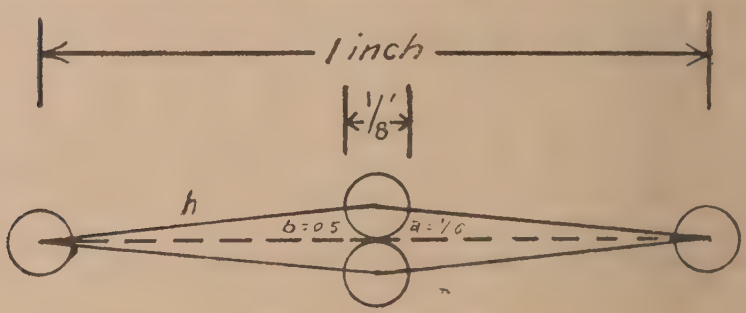


FIG. 3. True Mesh Size

size of the one inch stretched mesh with a knot one-eighth inch thick is not exactly one inch long as per stretched measurement but is actually 1.008 inches long as proven in the following:,

$h^2 =$	$(a)^2 \div (b)^2$	$h = \sqrt{0.253906}$	
$h^2 =$	$(1/16)^2 \div (.5)^2$	$h =$	0.504
$h = \sqrt{(1/16)^2 \div (.5)^2}$		$2h =$	1.008 inches

In this particular case, the true length (2h) is 1.008 inches or 0.8 per cent longer than the stretched length.

The stretched length of a mesh is, therefore, not the same as the true length. The former is shorter than the latter depending on the size of twine and type of knot used. The effect of the thickness of the knots is evident when two pieces of one-inch nettings are compared, one constructed from fine threads, and the other from heavy twines. Both have one-inch

mesh but the latter appears smaller than the former. This is because the stretched length of a mesh is shorter than the true mesh size.

It is, therefore, more accurate to measure mesh size by the bar length method where the true length is equal to twice the bar length. Hanging length of the mesh should also be measured accordingly.

It should not be measured in stretched condition as its true length is really equal to the length of the two bars measured from center to center of the knots. When stretched, the straight distance from the first to the end knot is shorter than the true length of the mesh. One hundred per cent hung, therefore, should be taken to mean as 100 per cent of the true length and not 100 per cent of its stretched length.

When hung at a slack, the mesh becomes diamond-shaped depending on the degree of shrinkage, or per cent of hanging. Thickness of the knot affects the depth of the mesh only when it is hung at 100 per cent in stretched condition or when hung at a shrinkage of not more than the thickness of the knot.

Nettings are usually hung with a certain degree or percentage of slack depending on the type of gear and individual taste of the fisherman. They are never hung at 100 per cent of their length or zero per cent slack; nor zero per cent hung or 100 per cent slack.

Percentage of slack means the amount of shrinkage the hung length is shorter than the mesh length. Thus, in the 60 per cent hung (fig. 4) the mesh is hung 60 per cent of its true length, leaving 40 per cent as slack or shrinkage. The hanging length can be expressed either in percentage of slack or percentage of hung, each obtained by subtracting the other from 100 per cent, since they are complementary.

Depth of the mesh varies inversely to the hanging percentage. It increases when the hanging length is decreased and decreases when the hanging length is increased. At 100 per cent hung, the depth is equal to the thickness of the knot. At 60 per cent hung, the mesh is diamond-shaped with a depth of 80 per cent of the mesh length.

This is better understood by considering the two-inch mesh illustrated in fig. 5. At zero slack, the length is 100 per cent while the depth is theoretically zero. At full slack, the hung length is theoretically zero, while the hung depth is theoretically

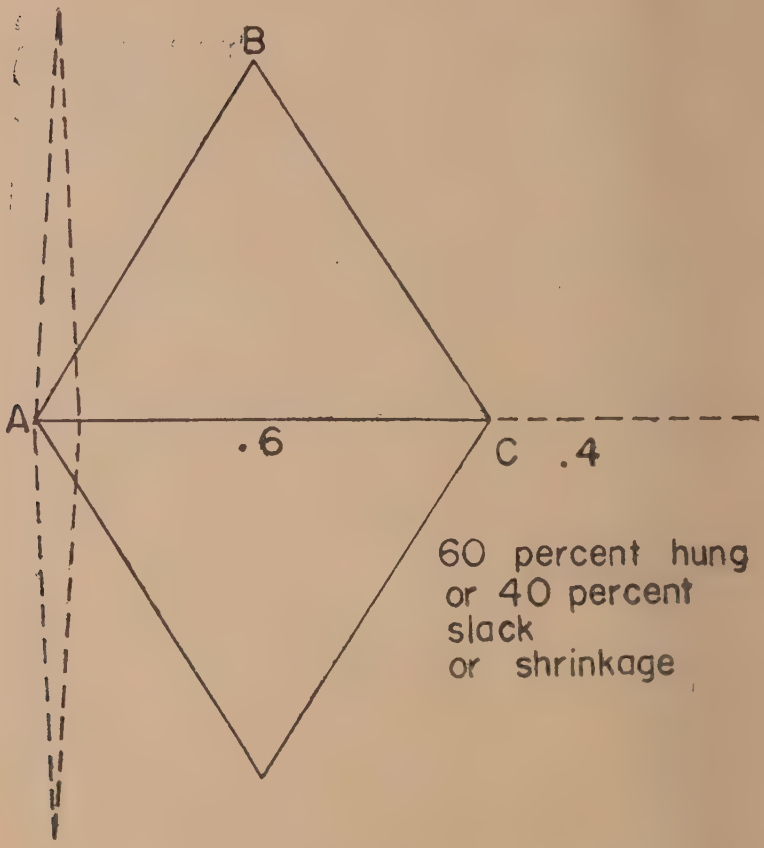


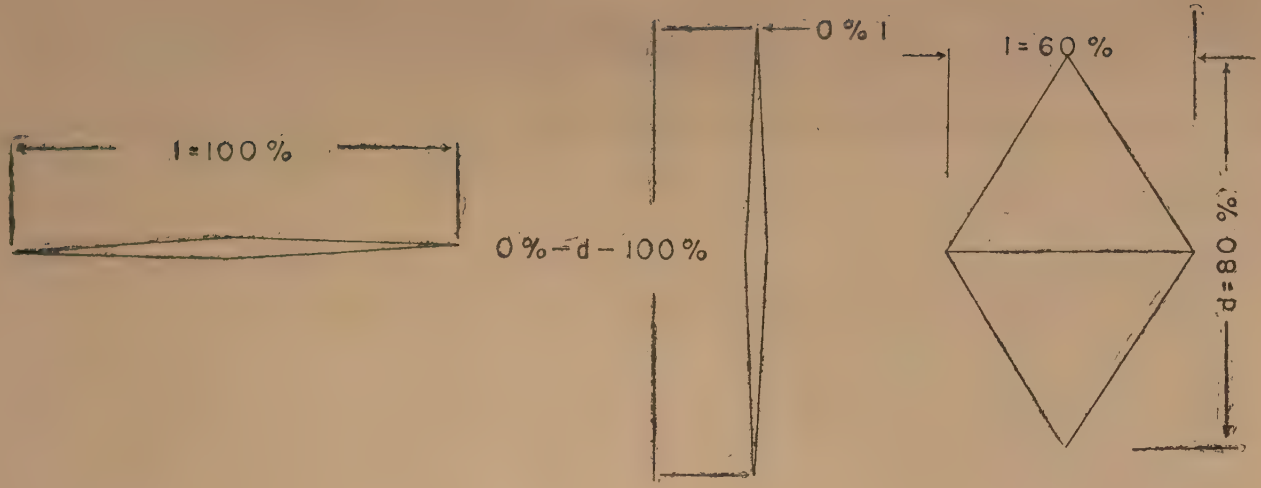
FIG. 4.

100 per cent. At 60 per cent hung, the hung length becomes 60 per cent while the hung depth becomes 80 per cent of the true mesh size.

When percentage hung is given, the variation in depth may be solved by Phytagorean theorem. In the one-inch mesh, 60 per cent hung, as shown in fig. 6, the hypotenuse C of the right triangle ABC is 1.0 inch long while the base B is 0.6 inch long. The altitude A representing the depth is solved. Thus:

1) $D = \sqrt{(1)^2 - .6^2}$ 2) $D = \sqrt{1. - .36}$

3) $D = \sqrt{.64}$ 4) $D = .8$



(a) Zero % slack or 100 % hung.

(b) 100 % slack or zero % hung.

(c) 40 % slack or 60 % hung.

FIG. 5. Hung length and Hung depth relationship

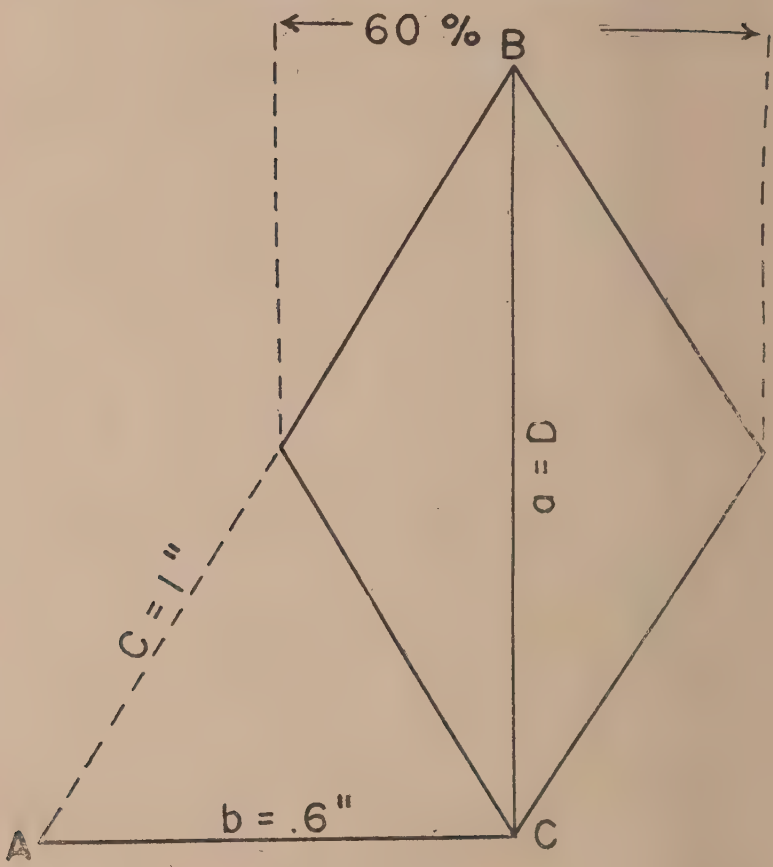


FIG. 6. Mesh depth

The formula: $D = \sqrt{1 - H^2}$ where D stands for depth, and H for length or percentage hung, can be used safely in determining the depth when the mesh is hung at a certain degree of slack. In triangle ABC (fig. 6) the hypotenuse *C* is 1.0 inch long and the sides *A* and *B* are equal to the length and depth, respectively. Since the square of the hypotenuse is equal to the sum of the squares of the sides, therefore;

$1^2 = H^2 + D^2$ $\qquad$ $D^2 = 1^2 - H^2$

$D = \sqrt{1^2 - H^2}$ $\qquad$ $D = \sqrt{1 - H^2}$

Thus, the formula mentioned is obtained.

The formula gives the depth of the netting whose hanging percentage is given as in the following problem: What is the depth in fathoms of a netting, 100 meshes deep, 5-inch mesh, when hung at 60 per cent?

Solution:

by formula ..... $D = \sqrt{1 - H^2}$
substituting ..... $D = \sqrt{1 - .6^2}$
solve for D ..... $D = 0.8$ or 80%
in inches ..... $= 5 \times 100 \times .8$ or 400
in fathoms ..... $= 5.5$

The formula may also be used in determining the hung when depth is given by interchanging the letters D and H, thus:

$H = \sqrt{1 - D^2}$ is obtained.

The application of the second formula is illustrated in the following problem:

What is the length of the hanging line for a 5-inch mesh netting, 100 meshes long, when the theoretical depth is 80 per cent of the stretched depth?

$H = \sqrt{1 - D^2}$

$H = \sqrt{1 - .8^2}$

$H = \sqrt{.36}$

$H = .6$ or 60%

in inches $= 6 \times 100 \times 0.6 = 300$

in fathoms $= 4.16$

Meshes are sometimes squarely hung, that is, the length is as long as the depth. For practical purposes, 70 per cent hung may be considered a square hung. However, the true square hung is at 70.71 per cent as proven in a squarely hung two-inch mesh (fig. 7) where, in the right triangle ABC, the hypotenuse C is one inch long and the base B and altitude A. representing $\frac{1}{2}$ the length and depth hung, respectively, are equal to each other.

The square of the hypotenuse C is equal to the sum of the squares of A and B. Since A and B, though equal are unknown, they can be represented by the letter 2x. Therefore, $1^2 = 2x^2$

$2x^2 = (1)^2$

$x^2 = 1/2$

$x = \sqrt{.5}$

$x = .7071$

or

70.71%

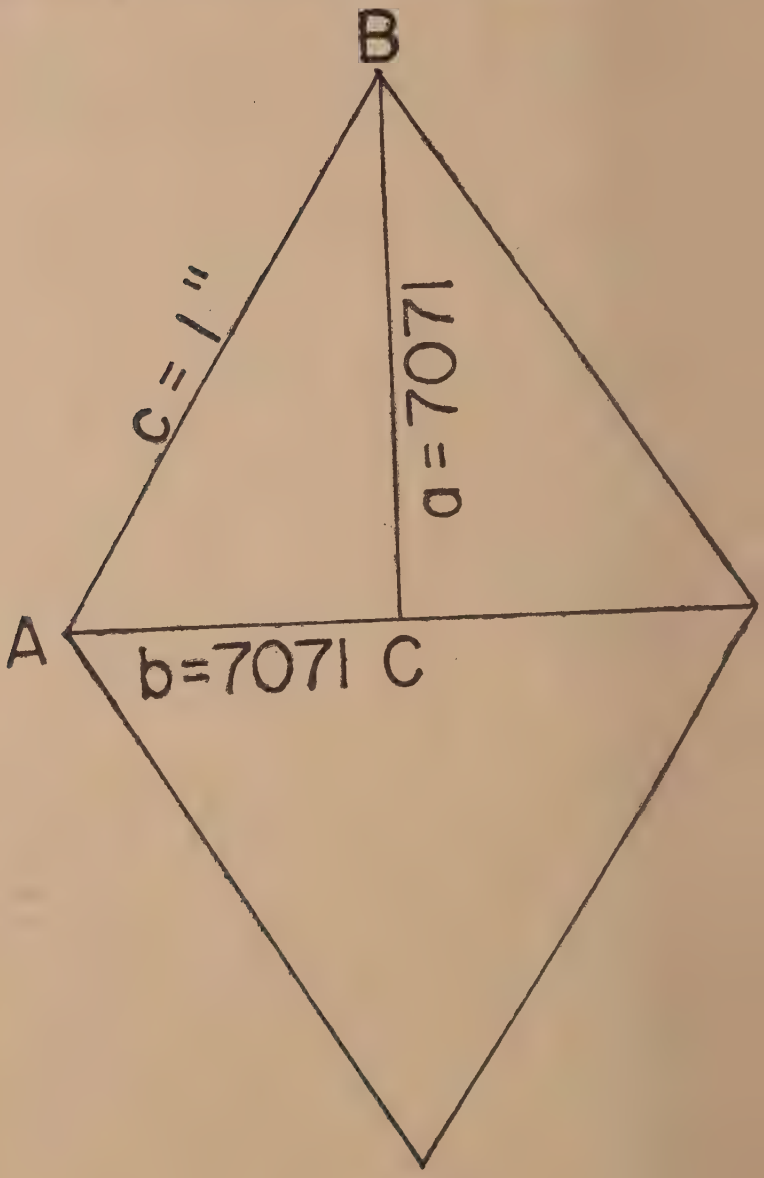


FIG. 7. Square hung

This proves that the mesh is squarely hung at 70.71 per cent.

It has been shown in the foregoing discussion that it is wrong to measure the size of a mesh in stretched condition. The true size is equal to twice the length of any one of its bars or legs measured from the center of the knots. This correction in the manner of measuring mesh size eliminates the error of the conventional stretched measurement in determining the corresponding depth and length of the net after hanging it at any given percentage.

It is common knowledge that when the hanging line is as long as the size of the mesh, the depth becomes zero or the "eye is closed." However, when the hanging line is increasingly decreased, the depth also increases or the "eye opens" up to the degree when the square hung condition is attained, after which, the "eye closes" again. This relationship is shown in the accompanying Table 1, a guide table for length and depth relationship in per cent of a mesh after hanging, based on the true mesh size measurement discussed above. The table has three columns, namely:

1. Per cent hung—gives the hanging length in per cent of the mesh size.
2. Per cent slack—gives the amount of slack or shrinkage in per cent of any given percentage hung from 100 per cent.
3. Per cent depth—shows the depth in per cent when hung at any given degree of per cent slack.

The table is useful in determining the length of the hanging line for a given netting. It determines the depth of the netting after hanging and also the exact amount of netting necessary to construct a fishing gear when the hanging line and depth after hanging are given. Thus, at 60 per cent hung, the hanging percentage most commonly used, the depth of one-inch mesh by 100 meshes deep netting is equal to $1 \times 100 \times 0.8$ or 80 inches, while the length is equal to $1 \times 100 \times 0.6$ or 60 inches.

Fishermen never hang their net at zero nor 100 per cent. Hence, zero and 100 per cent hung are not included in the table. The hanging per cent usually used is from 35–70, 50–65 per cent being more common.

Length and depth relationship of mesh when hung

Per cent Hung	Per cent slack or shrinkage	Depth in Per cent	Per cent Hung	Per cent slack or shrinkage	Depth in Per cent
1	99	99.995	51	49	86.0
2	98	99.98	52	48	85.4
3	97	99.95	53	47	84.8
4	96	99.92	54	46	84.1
5	95	99.9	55	45	83.5
6	94	99.8	56	44	82.8
7	93	99.7	57	43	82.1
8	92	99.7	58	42	81.4
9	91	99.6	59	41	80.7
10	90	99.5	60	40	80.0
11	89	99.4	61	39	79.2
12	88	99.3	62	38	78.4
13	87	99.1	63	37	77.6
14	86	99.0	64	36	76.8
15	85	98.8	65	35	76.0
16	84	98.7	66	34	75.1
17	83	98.5	67	33	74.2
18	82	98.3	68	32	73.3
19	81	98.2	69	31	72.4
20	80	98.0	70	30	71.4
21	79	97.8	71	29	70.4
22	78	97.5	72	28	69.4
23	77	97.3	73	27	68.3
24	76	97.1	74	26	67.2
25	75	96.8	75	25	66.1
26	74	96.6	76	24	65.0
27	73	96.3	77	23	63.8
28	72	96.0	78	22	62.5
29	71	95.7	79	21	61.3
30	70	65.4	80	20	60.0
31	69	95.1	81	19	58.6
32	68	94.7	82	18	57.2
33	67	94.4	83	17	55.7
34	66	94.0	84	16	54.2
35	65	93.6	85	15	52.7
36	64	93.3	86	14	51.0
37	63	92.9	87	13	49.3
38	62	92.5	88	12	47.5
39	61	92.2	89	11	45.6
40	60	91.6	90	10	43.6
41	59	91.2	91	9	41.5
42	58	90.9	92	8	39.2
43	57	90.3	93	7	36.7
44	56	89.8	94	6	34.1
45	55	89.9	95	5	31.2
46	54	88.8	96	4	28.0
47	53	88.2	97	3	24.3
48	52	87.7	98	2	19.9
49	51	87.1	99	1	14.1
50	50	86.5			

ILLUSTRATIONS

TEXT FIGURES

FIG. 1. Stretched measure.
2. Bar × 2 measurement-solid line stretched length-dotted line.
3. True mesh size.
4. Sixty-per-cent hung or 40 per cent slack or shrinkage.
5. Hung length and hung depth relationship.
6. Mesh depth.
7. Square hung.

ON THE AVAILABILITY OF FISH OF THE FAMILY LEIOGNATHIDÆ LACEPEDE IN MANILA BAY AND SAN MIGUEL BAY AND ON THEIR ACCESSIBILITY TO CONTROVERSIAL FISHING GEARS.

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Of the Fisheries Research Division of the Bureau of Fisheries

TWO PLATES AND SIXTEEN TEXT FIGURES

INTRODUCTION

Since November 1956, studies on the biology of Leiognathidæ have formed part of the researches of the Bureau of Fisheries which were initiated with the assistance of the FAO Technical Assistance Program.(5) Although slipmouths represent the most abundant group of demersal fishes in Manila Bay and in general also in most of the other coastal trawling grounds of Philippine waters, this interesting family of fish has never been the object of detailed studies. Researches became desirable in view of a controversy on the proper management of demersal fish stocks which had arisen between the commercial otter trawl operators and the sustenance fishermen and in which the latter group alleged that the trawlers in Manila Bay and other areas were depleting the demersal fish stocks. They proposed to totally ban trawl fishing in these areas. Inasmuch as certain species of slipmouths, Leiognathidæ, also form the main catch of fish corrals of sustenance fishermen in Manila Bay, studies had to be directed chiefly to determine the availability of Leiognathidæ and their accessibility to the controversial gears. This paper contains the results of this investigation which have considerably helped in the meanwhile to solve the so-called otter trawl controversy and will form, together with other investigations, the basis for a monograph on the fishery resources of Manila Bay which is one of the most important fishing areas of the Philippines. Other results obtained on the biology of the slipmouth shall be published in further papers.

The writers gratefully acknowledge the unstinted cooperation given by the members of the Interisland Deep-sea Fishing

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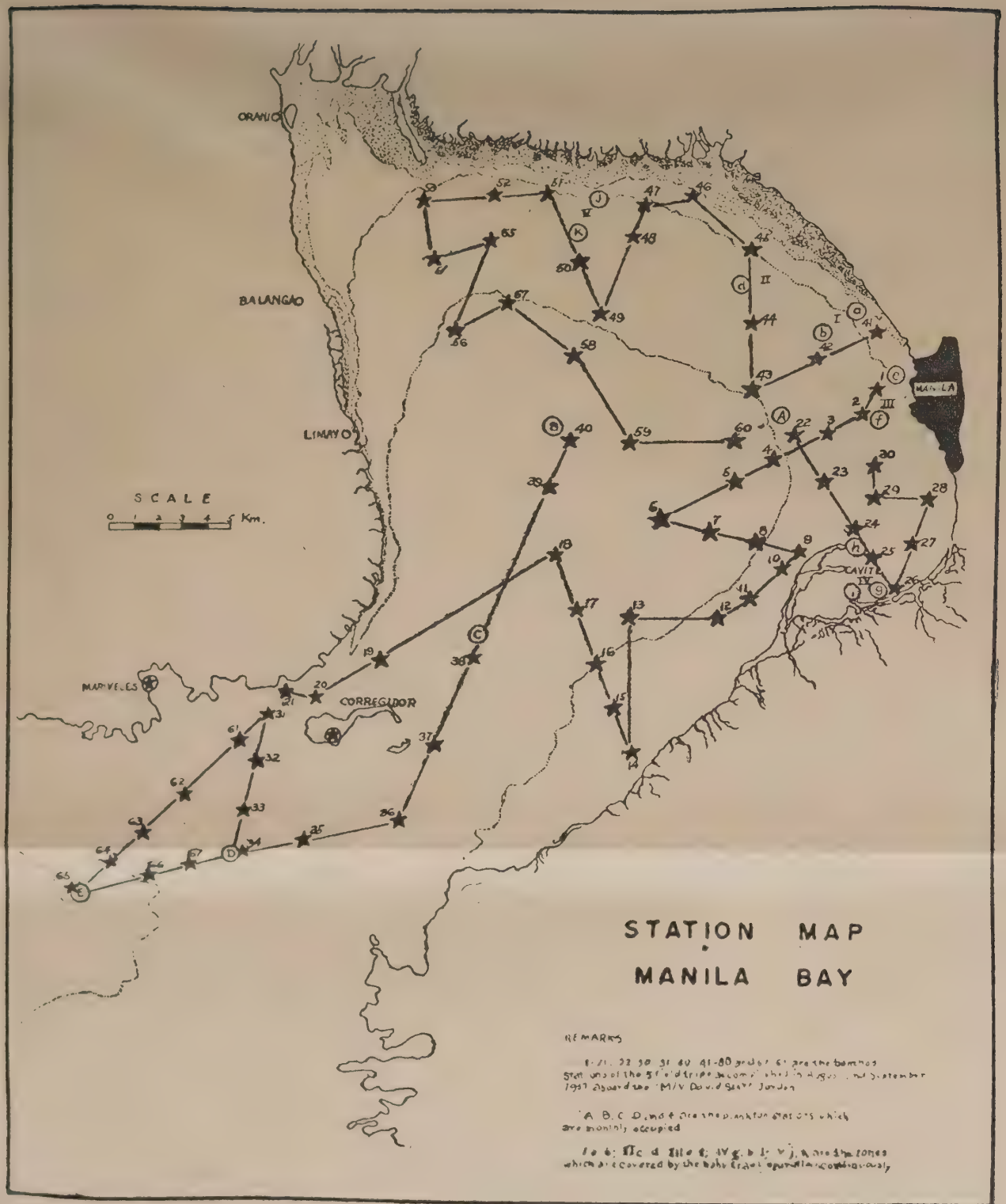
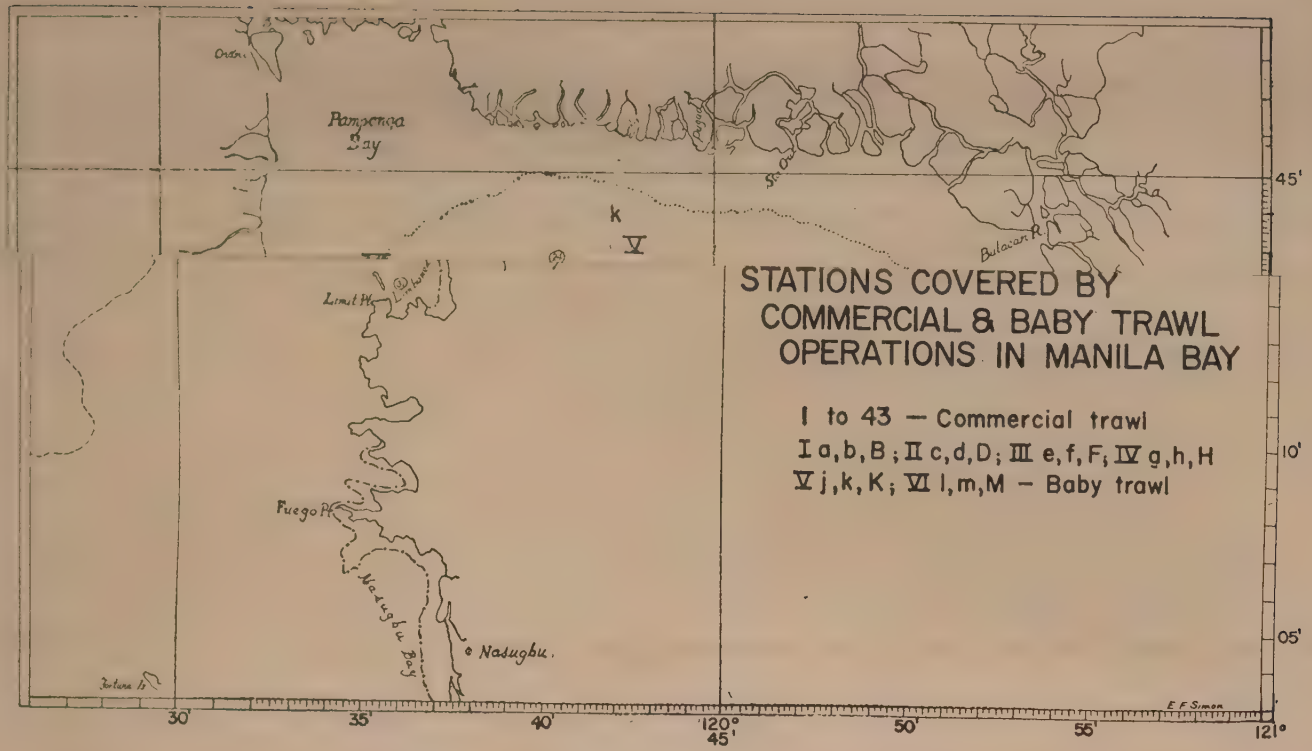
Association headed by Mr. Ildefonso Lachenal in providing the samples used in this study, the United Nations Expanded Technical Assistance Program, the National Economic Council, the National Research Council, and the National Science Development Board for financial and material aid, and the members of the Hydrology and Fisheries Biology Staff without which this research would not have been possible.

MATERIALS

Since one of the main objectives of this investigation was to study the distribution of the species of Leiognathidæ in the fishing grounds in which the three controversial gears, namely, otter trawl nets, baby trawl nets and fish corrals are operated, it became necessary to develop a three-cornered sampling program. The lack of a suitable research vessel with which to survey the deeper parts of Manila Bay was compensated by a close collaboration with the otter trawl fishery consisting of 50 units which has to be acknowledged with gratitude. From November 1956 to October 1958, 43 field trips were carried out by a two-three men team aboard otter trawl boats, each trip lasting from three to five days. Random samples of slipmouths at known localities were immediately taken soon after the hauling of nets. Figure 1 shows the more common trawling grounds covered by vessels during these field trips. Samples were preserved in 4 per cent formalin solution after all other kinds of fish were sorted out and brought to the shore laboratories at the Dagatdagatan Fisheries Research Station for analyses. The sampling gear in this case was the typical otter trawl as described by Manacop.(2) Measurements of the cod ends of the wet nets from which samples were taken revealed that all fishing boats boarded for this purpose used a similar mesh size of about 3.2–2.8 centimeters ($1\frac{1}{4}$–$1\frac{1}{2}$ inches) from knot to knot.

In order to complete the data obtained from the study of the catch composition of otter trawls, the operation of a miniature otter trawl used in the shallower parts of the bay up to 5 fathoms, the so-called "dug-out" or baby trawl as described by Manacop and Laron (3) was started in April 1957 with a motor boat borrowed from the Philippine Institute of Fisheries Technology, now College of Fisheries, U. P. In September 1957, a basnigan type banca, 11 meters overall length and 1 meter beam equipped with a 25 H. P. Continental gasoline engine,


ORANI
BALANGAO
LIMAY
MARIVELES
CORREGIDOR
MANILA
CAVITE
SCALE
0 1 2 3 4 5 Km.
STATION MAP
MANILA BAY
REMARKS
1. 21, 22, 30, 31, 40, 41-80 and b, c, f are the bamboo
Stations of the 5th field trips accomplished in August and September
1957 aboard the M/V David Starr Jordan
A, B, C, D, and E are the plankton stations which
are monthly occupied
I, II, III, IV, V, a, b, c, d, e, f, g, h, i, j, k are the zones
which are covered by the baby trawl operations continuously


Pampanga Bay
Limit Pt.
Fuego Pt.
Nasugbu Bay
Nasugbu
Bulacan R.
k
V
STATIONS COVERED BY COMMERCIAL & BABY TRAWL OPERATIONS IN MANILA BAY
1 to 43 — Commercial trawl
I a,b,B ; II c,d,D ; III e,f,F ; IV g,h,H
V j,k,K ; VI l,m,M — Baby trawl
45'
10'
05'
30'
35'
40'
120° 45'
50'
55'
121°
E.F. Simon

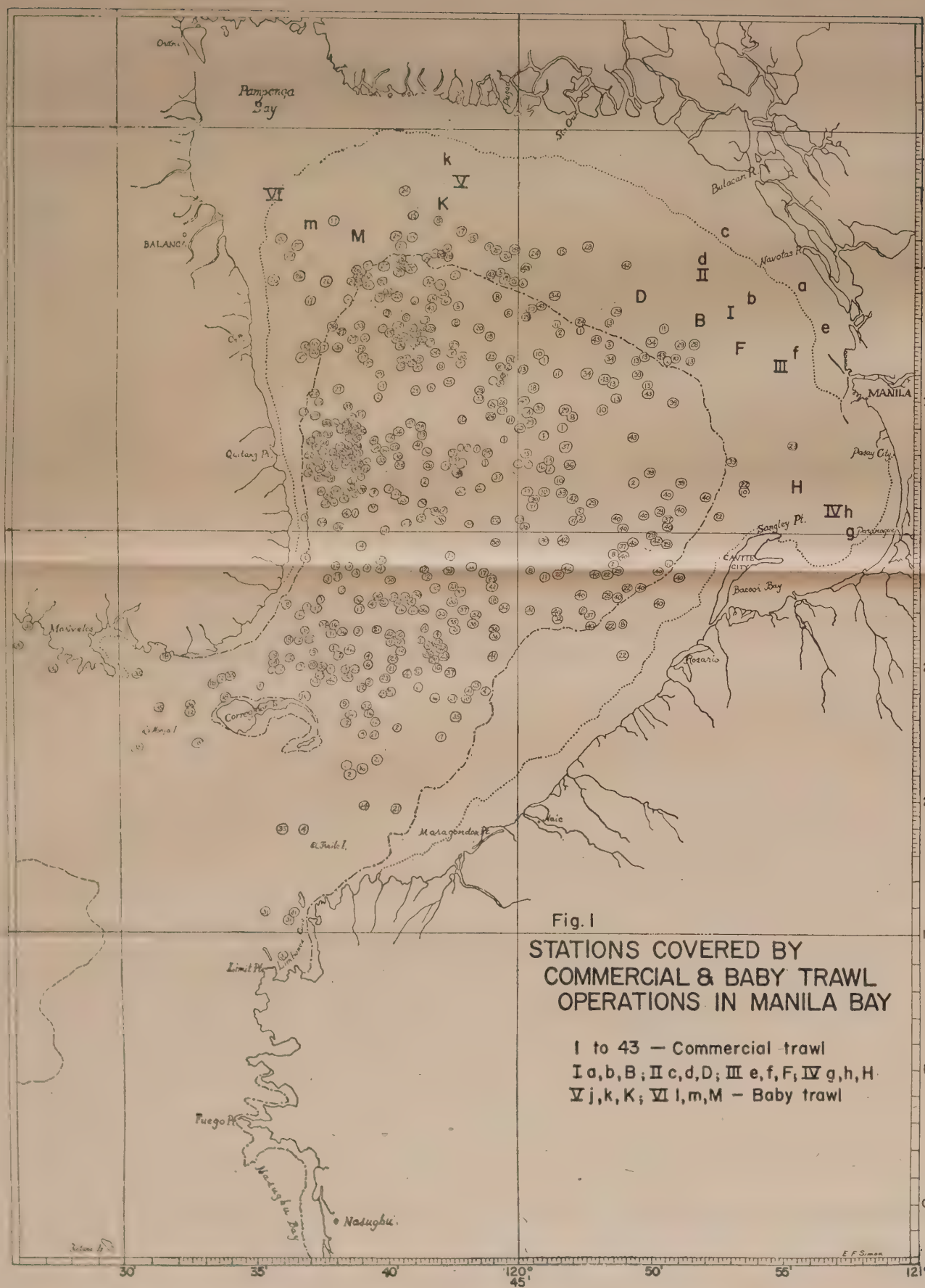


Fig. 1

STATIONS COVERED BY COMMERCIAL & BABY TRAWL OPERATIONS IN MANILA BAY

1 to 43 — Commercial trawl

I a, b, B; II c, d, D; III e, f, F; IV g, h, H

V j, k, K; VI l, m, M — Baby trawl

was purchased for this purpose and hereinafter operations were extended to the 8 fathoms depth. From April 1957 to October 1958, 149 one-day experimental fishing trips were carried out and 703 hauls of half-hour drags were made every other week on 6 fixed stations along the coast of Manila Bay between Cavite and Bataan on the 2, 5, and 8 fathoms line (fig. 1).

Since October 1957, apart from the standard net with mesh size of ¾ inch in its cod end, additional nets of mesh sizes of 1¼, 1½, 1¾, 2, 2¼, and 2¾ inches in the cod ends were made and used in order to investigate the selectivity of this mesh. All pertinent data on this experimental fishing were recorded and the catches were preserved and studied in detail in the shore laboratories.

A third source of research material were the fish corrals, which are operated in the coastal parts of the bay ranging from 1 to 8 fathoms. Catch samples from fish corrals of Navotas were analyzed for comparison in this study. From January to June 1957, which was the latter part of the fish corral season, 11 unsorted samples representing a day's catch each were taken weekly and from October 1957 to May 1958, 24 weekly samples were analyzed in the laboratory. In order to check the differences in the catch of this gear, 3 samples were secured from fish corrals in Bataan province situated across Manila Bay opposite Navotas town.

Aside from this main sampling program, a smaller program was carried out in San Miguel Bay on the Pacific side of Southern Luzon in June and October 1957 and February and May 1958 aboard otter trawlers. During this period, 21 samples were taken in and outside this Bay. Furthermore, in October 1957, 4 samples were taken from Dasol Bay which lies south of Lingayen Gulf. Table I shows the collected materials analyzed.

IDENTITY OF SPECIES

The family Leiognathidæ is one of the families of the Division Perciformes of the Sub-order Percidea, belonging to the order Percomorphi. It was decided to follow Herre(1), Munro (4) and others who do not include the generæ *Gerres* and *Pentaprion* in the family Leiognathidæ. Only the genera *Leiognathus* Lacépéde (1803) and *Gazza* Ruppell (1835) are included under Leiognathidæ. The general description of

TABLE 1.—*Specimens of Leiognathidae collected and analyzed from November 1952 to October 1953.*

Type of Fishing Gear	Area	No. of Trips	No. of Specimens	No. of Specimens
Otter Trawl	Manila Bay	80	7,000	3,000
	Dasol Bay	7	700	300
	Lingayen Gulf	12	1,200	500
Fish corral	Dasol Bay	100	4,000	1,500
Fish pound	Lingayen Gulf	10	500	200
	Manila Bay	5	300	100
	Total	214	13,700	5,600

Munro (1955) is: "Body compressed and shiny with minute scales which are not easily visible. Gill membranes united with isthmus. Mouth extremely protractible. Teeth usually small in jaws, sometimes with larger canines; absent from palate. Dorsal and anal with basal sheath. Extrude large amounts of mucus after death . . . Top of head with bony ridges and a nuchal spine."

Herre(4) includes in his "Check List of Philippine Fishes", 2 species of *Gazza* and 16 species of *Leiognathus*. All species he mentioned were found during the course of this study, except *L. stercorarius* Evermann and Seale which Herre himself reports: "Confused by authors with *L. elongatus*", and *L. edwardsi* Evermann and Seale which according to Herre "only the type is known". The record of 14 species of *Leiognathus* in Philippine waters is, therefore, valid. The existence of *L. edwardsi* is doubtful. Weber and de Beaufort(7) do not include this species. A 15th species, *L. smithursti* (Rams. & Ogilby), which is not included in Herre's Checklist of Philippine Fishes but is recorded in the key of Weber and de Beaufort(7) as found in New Guinea (Hood Loguce) and in Fiji, has been found for the first time in Philippine waters during this study, but only in San Miguel Bay and not in Manila Bay nor Dasol Bay.

Although two species of *Gazza* are included in the following key of Philippine Leiognathidae, there is some doubt as to whether only one species actually exists, inasmuch as the principal distinguishing characters, namely, the height of the body, the length of the second dorsal and anal fins and the size of the canines were doubted by Leunzinger in 1871 and again in 1884. However, Munro(4) believes that the two species can be distinguished while Weber and de Beaufort(7) unite both to the species *Gazza minuta*. The distinction of the species was found

to be difficult by the existing keys(4), (7) so that it became desirable to devise a new and simpler key.

Since there exists a great uniformity in meristic counts of finrays in the whole family of Leiognathidæ, the species are mainly described by their body form and their coloration. The relationship of body height to standard length has been most carefully checked especially for younger specimens since the body form changes considerably in some of the species.

Below is the working key used to separate the species studied.

Key to the family of Philippine Leiognathidæ

1. Teeth include distinct canines *Gazza* Ruppell.
   A. Depth 2.6–2.8 in standard length ..... *G.* (Bloch).
   A'. Depth 1.8 in standard length .... *G.* (Jaran and Starks).

1'. Teeth minute without canines *Leiognathus* Lacepede.
   B. Mouth very much oblique, when protracted forming an upwardly directed tube.
      C. Depth 1.5–1.9 in standard length ..... *L.* (Hamilton ne Buchanan)
      C'. Depth 2.0–3.0 in standard length ..... *L.* (Bloch)
   B'. Mouth horizontal or directed downwards, when protracted.
      D. Depth more than three times in standard length; cheeks scaly ..... *L. elongatus* (Gunther).
      D'. Depth less than three times in standard length; cheeks not scaly.
         E. Second dorsal spine elongated, longer than half height of body.
            F. Dorsal profile much more convex than ventral: depth 1.6 2.0 in standard length.
               G. Mandible strongly concave: second dorsal spine not much longer than half height of body; diffuse irregular vertical bands somewhat evenly spaced in upper half of body ..... *L. fasciatus* (Lacepede).
               G'. Mandible slightly concave; second dorsal spine longer than half of the total length of body; second anal spine also greatly elongated; few washed bands unevenly spaced ..... *L.* (Rams. & Ocillo).
            F'. Dorsal profile only slightly more convex than ventral; depth 2.0–2.6 in standard length; vertical bands. *L. leuciscus* (Gunther).
         E'. Second dorsal spine half height of body depth or less
            H. Mandible strongly concave.
               I. Dorsal profile much more convex than ventral; depth 1.5–1.7 in standard length .... *L. equulus* (Forskal).
               I'. Dorsal profile only slightly more convex than ventral, depth 1.8–2.2 in standard length.
                  J. Silvery belly, base of pectoral yellow ..... *L.* (Cuvier & Valenciennes).

J_2. Silvery color is absent, a narrow yellow band from above eye to base of caudal, dark transverse blotch across nape, base of pectoral black .... *L. brevirostris* (Cuvier & Valenciennes).

H_2. Mandible slightly or not concave.

K_1. Dorsal profile more convex than ventral, depth 1.5–1.9 in standard length.

I_1. Lateral line commences with a concavity curving somewhat upwards and running less convex than dorsal profile to base of caudal, dark vertical bands on its back, silvery and yellow color lacking .... *L. dussumieri* (Cuvier & Valenciennes).

L_2. Lateral line without concavity, color silvery, wavy lines on dorsal side, yellow coloration on lateral line, pectoral, anal, dorsal and caudal fins .... *L. splendens* (Cuvier).

K_2. Dorsal profile less convex than ventral, depth 1.6–2.5 in standard length ..... *L. bindus* (Cuvier & Valenciennes).

K_3. Dorsal and ventral profile more or less equal.

M_1. Blunt snout, predominant black spot from 2nd to 5th or 6th dorsal spine, color silvery with golden stripes along side ..... *L. daura* (Cuvier.)

M_2. Pointed snout, no black spot on dorsal fin, golden stripes absent.

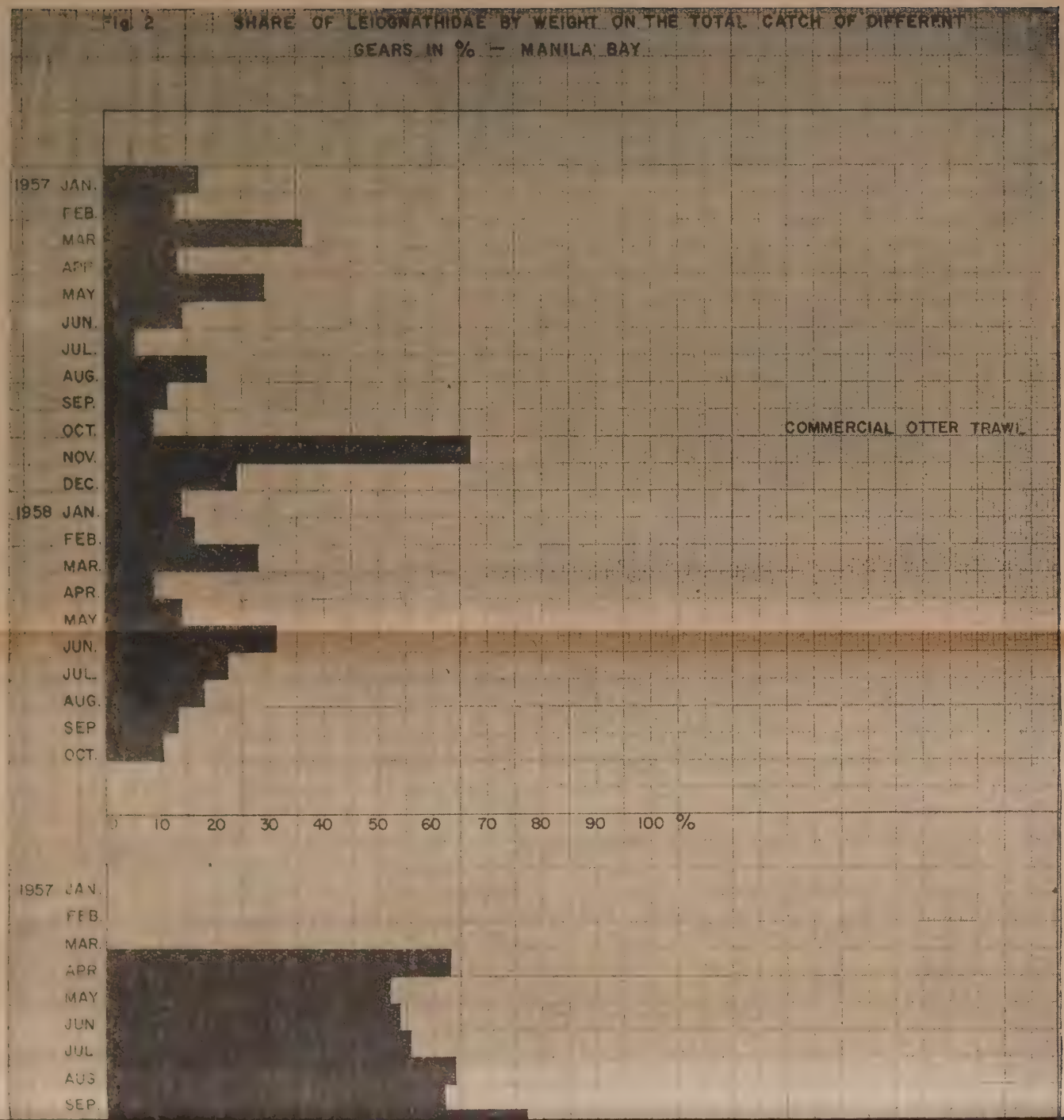
N_1. Rostro-occipital profile ascending in a straight line with a slight frontal concavity, depth 2.0–3.0 in standard length, color silvery with irregular dark spots on the dorsal side .... *L. lineolatus* (Cuvier & Valenciennes).

N_2. Rostro-occipital profile ascending in a nearly straight line without concavity, depth 2.0–2.3 in standard length, color silvery with irregular dark spots and rather broad more or less angulated lines, some serially arranged ..... *L. berbis* (Cuvier & Valenciennes).

POPULATION, ITS ACCESSIBILITY TO DIFFERENT FISHING GEARS AND ITS STRUCTURE IN MANILA BAY

Catch composition and its seasonal changes.—Table 2 shows the monthly share of the species of the family Leiognathidæ on the total catch of the different gears based on the analysis of catches from 43 otter trawl field trips, 149 baby trawl trips and 38 fish corral samples. It will be noted that the share of slipmouths by weight on the total catch was lowest in the otter trawl fishery, namely, between 5.2 and 36.5 per cent (exceptionally high, 67.7 per cent, in November 1957). The baby trawl slipmouth catches showed a share of 50 to 90 per cent.

Fig 2 SHARE OF LEIOGNATHIDAE BY WEIGHT ON THE TOTAL CATCH OF DIFFERENT GEARS IN % — MANILA BAY



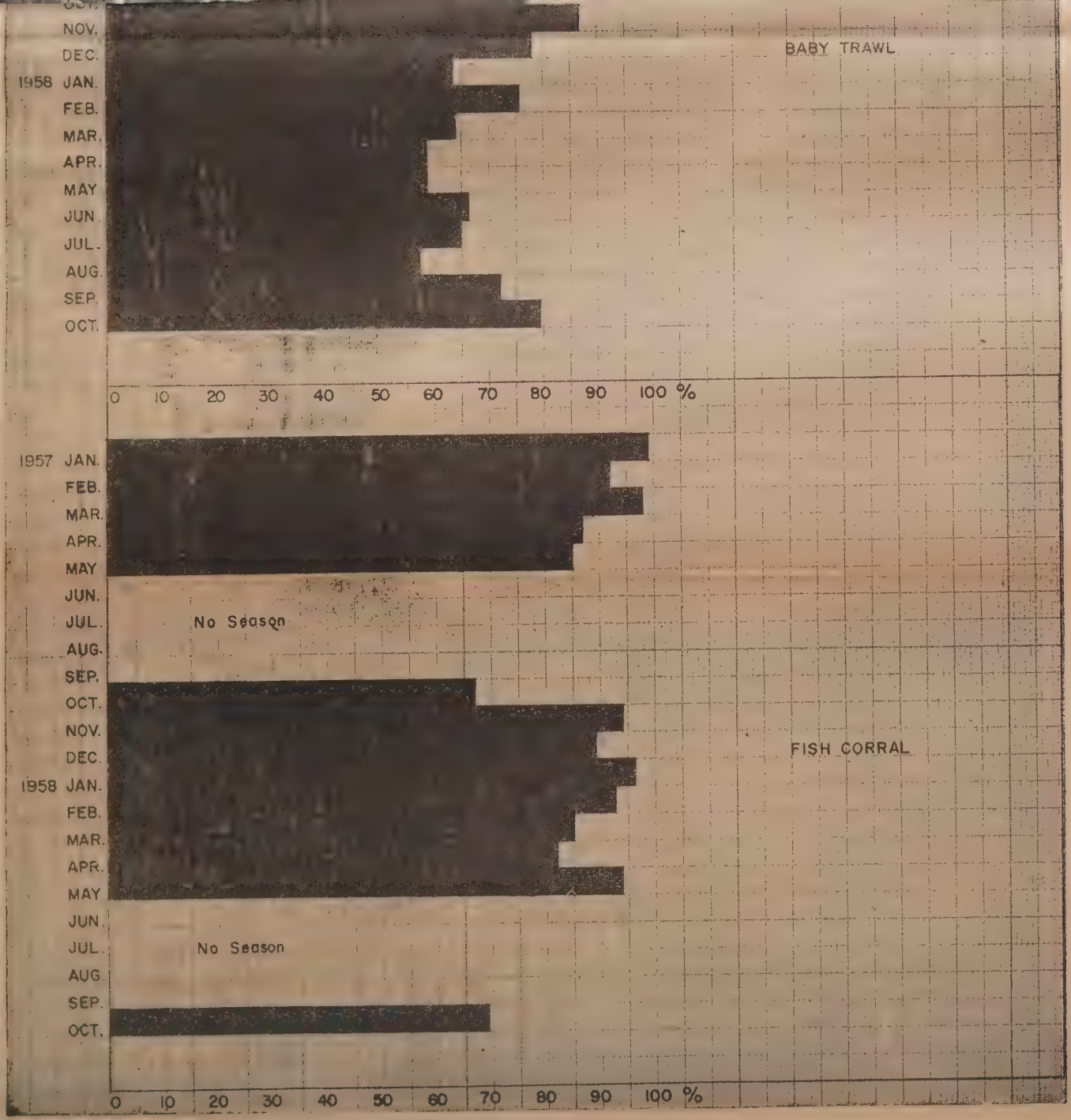

NOV.
DEC.
1958 JAN.
FEB.
MAR.
APR.
MAY
JUN.
JUL.
AUG.
SEP.
OCT.
BABY TRAWL
0 10 20 30 40 50 60 70 80 90 100 %
1957 JAN.
FEB.
MAR.
APR.
MAY
JUN.
JUL.
AUG.
SEP.
OCT.
NOV.
DEC.
1958 JAN.
FEB.
MAR.
APR.
MAY
JUN.
JUL.
AUG.
SEP.
OCT.
No Season
No Season
FISH CORRAL
0 10 20 30 40 50 60 70 80 90 100 %

TABLE 2.—*Monthly share of Leiognathidae by weight on the total catch in Manila Bay (per cent).*

Month	Otter trawl		Baby trawl		Fish corral (Navotas)	
	No. of Haul's Studied	Share	No. of Hauls Studied	Share	No. of Samples Studied	Share
		Per cent		*Per cent*		*Per cent*
January '57	27	17.8	--------	--------	2	99.5
February	29	18.4	--------	--------	2	92.1
March	16	36.5	--------	--------	2	98.9
April	33	12.9	25	63.5	4	87.8
May	28	29.7	8	52.4	1	85.2
June	25	14.5	13	54.2	a	----------
July	27	5.2	24	56.7	a	----------
August	28	18.8	20	64.5	a	----------
September	31	11.8	26	62.7	a	----------
October	28	9.4	17	77.5	2	67.9
November	24	67.7	24	87.3	1	94.4
December	27	24.6	17	78.3	3	90.0
January '58	33	14.2	16	63.6	4	96.8
February	29	16.8	22	76.1	4	93.6
March	11	28.2	30	64.4	4	85.5
April	28	9.4	33	58.6	5	2.7
May	29	14.7	30	58.4	2	94.7
June	26	31.6	27	66.3	a	----------
July	10	22.7	30	64.9	a	----------
August	34	18.7	30	57.5	a	----------
September	26	13.3	11	72.4	a	----------
October	11	10.7	30	79.8	3	69.7

The fish corrals had the highest percentage of slipmouths in their catches (fig. 2). In 12 out of 14 months of study the share was higher than 80 per cent and in 8 months even higher than 90 per cent up to nearly 100 per cent. It is obvious that the fish corral fishery of Navotas depends nearly exclusively on slipmouths while the commercial otter trawl fishery depends mainly upon stocks of other families of fish. Since the baby trawls fish in the same area where fish corrals are operated, it is not surprising that this gear also largely depends on slipmouth stocks. The comparison of the catches of the otter trawls and of the baby trawls, both gears only differing in size, shows a considerably higher relative abundance of slipmouths in the shallower parts of the bay below 8 fathoms than in deeper parts above 8 fathoms where trawlers are normally operated. The commercial trawlers chiefly catch fish of other families which obviously avoid the shallower parts of the bay and are not accessible to the sustenance fishermen operating fish corrals.

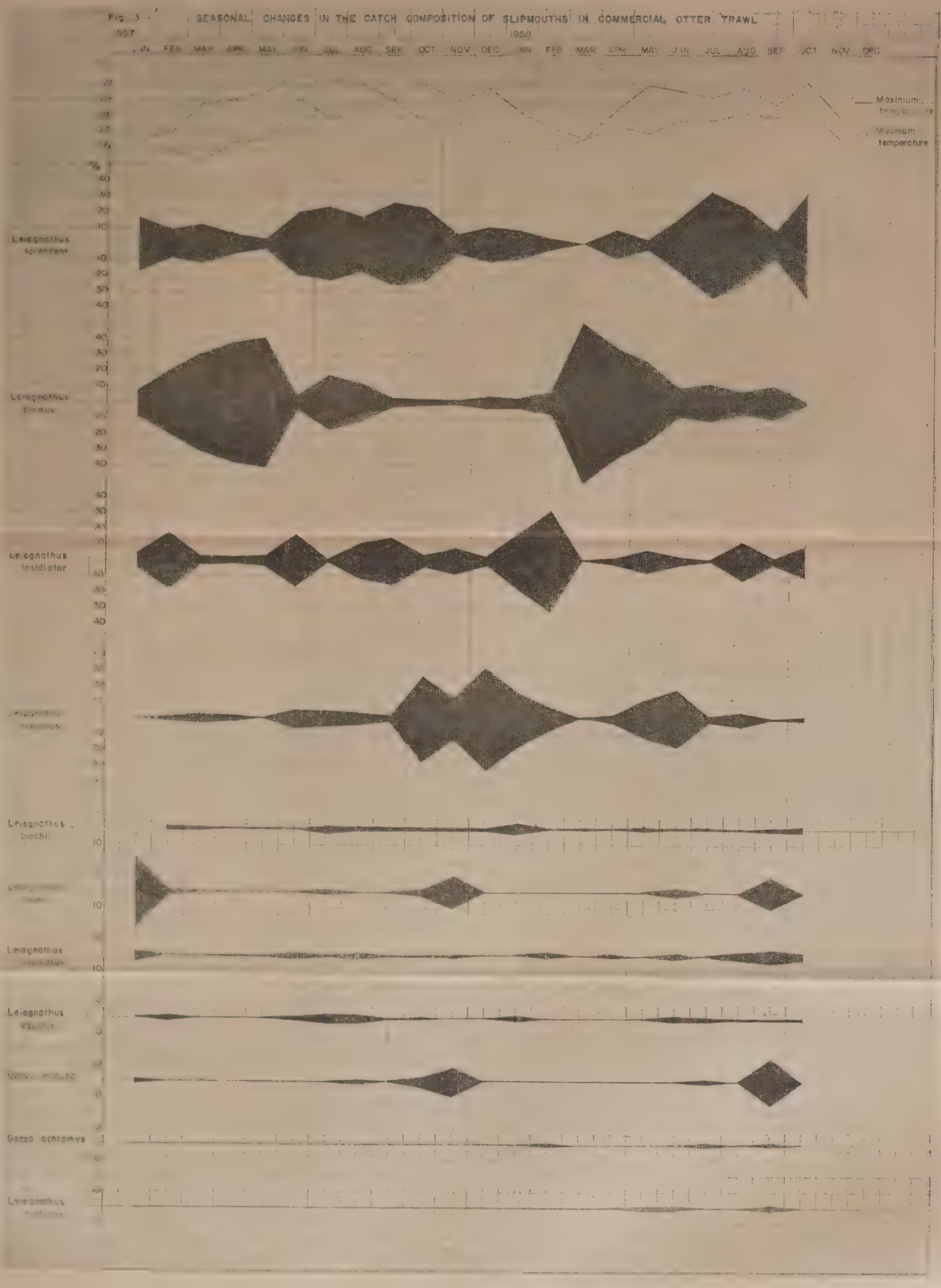
The shares of the different species of slipmouths on the total catch of Leiognathidae for the different gears are shown in Tables 3, 4, and 5.

Table 3 shows the contribution of the different species on the monthly catch of the fish corrals. *L. splendens* was dominant

TABLE 3.—*Shares of the species of Leiognathidæ by number on the total catch of fish corrals (per cent)*

Month	*L. splendens*	*L. bindus*	*L. insidiator*	*L. ruconius*	*L. blochii*	*L. daura*	*L. lineolatus*	*L. equulus*	*Gazza minuta*	*Gazza achlamys*	No. of Samples
January, *1957*	98.1	0.1	1.8	--------	--------	--------	--------	--------	--------	--------	2
February	76.6	2.5	20.9	--------	--------	--------	--------	--------	--------	--------	2
March	91.3	0.7	0.7	--------	4.5	--------	--------	2.8	--------	--------	4
April	75.5	23.0	1.0	0.2	--------	--------	--------	0.2	--------	--------	1
October	78.4	13.0	6.8	1.4	0.07	--------	--------	0.03	0.04	--------	2
November	7.2	6.8	85.5	0.1	0.1	--------	0.1	--------	--------	--------	1
December	79.9	3.3	14.6	0.2	0.3	0.01	0.3	0.04	1.4	--------	3
January, *1958*	**98.4**	**0.9**	**0.2**	**0.4**	**0.07**	**0.08**	**0.01**	**0.01**	--------	**0.1**	4
February	88.7	1.8	2.1	6.2	0.2	0.6	0.03	0.2	--------	0.05	4
March	78.0	16.6	3.8	0.02	0.7	0.1	0	0.5	0.2	0.5	4
April	73.4	14.6	7.9	0.9	0.8	2.2	0.2	0.3	--------	0.1	5
May	96.5	0.8	0.3	1.4	0.4	0.09	0.4	0.06	--------	0.03	1
October	89.1	4.0	0.3	0.2	0.3	0.3	4.9	0.1	0.2	0.3	3

Fig. 3 — SEASONAL CHANGES IN THE CATCH COMPOSITION OF SLIPMOUTHS IN COMMERCIAL OTTER TRAWL



in all months with shares above 70 per cent up to 98 per cent except November 1957 when *L. insidiater* became most dominant, contributing some 85.5 per cent of the total catch indicating a more accidental migration of this species to the shallower part of the Bay. From May until October during the SW monsoon season, this fishery is out of season at Navotas since the strong wind would destroy the fish corrals. Aside from *L. splendens* all other slipmouth species occur in lesser frequency in fish corrals. *L. bindus* and *L. insidiator* occasionally do enter fish corrals in large schools. There exists, most likely, a difference in the behavior of the different species to enter fish corrals. *L. ruconius* may be the best example for this. Although present in large quantities in the area of fish corrals as to be concluded from the catch analysis of the baby trawl operations (Table 4), the fish apeared in greater numbers only in February 1957 when it reached a share of 6.2 per cent on the total catch (Table 3). Likewise, *L. daura,* which kept a share of 17–18 per cent in the baby trawl catches in March and April 1958, was also seldom found in fish corral catches.

The baby trawl catches likely represent the true picture of abundance of species in the shallower area better than the fish corral catches inasmuch as it is a moving gear. The dominant species were *L. splendens* and *L. ruconius. L. splendens* was the abundant species in most of the months, except in May, August and September, 1957 when *L. ruconius* took its place as the most abundant species, and from December 1957 until March 1958 when the two above-mentioned species were found to be equally abundant in the catch. As can be seen in Table 4, *L. daura, L. bindus, L. insidiator, L. blochii, L. lineolatus, Gazza minuta,* and *L. equulus* are listed in the order of their abundance. The period of research is too short to recognize a characteristic yearly cycle in the abundance of species in shallower waters. However, the presence of such a cycle could be concluded for some specimens from the materials of the deeper waters (Table 5). Here, the otter trawl fishery mainly depends upon *L. splendens, L. insidiator,* and *L. ruconius.* The contributions of other species to the catch are insignificant.

Each of the abundant species *L. bindus, L. splendens, L. ruconius* and *L. insidiator* had a period of predominance in the catches. In addition to Table 5 which shows the monthly percentile share of the different species of slipmouths, Figure 3 demonstrates the seasonal changes in the catch composition

TABLE 4.—*Shares of species of Leiognathidæ (by number) on the total catch of baby trawl (per cent)*

Month	*L. splendens*	*L. bindus*	*L. insidiator*	*L. ruconius*	*L. blochii*	*L. daura*	*L. fasciatus*	*L. equulus*	*Gazza minuta*	*Gazza achlamys*	*L. leuciscus*	*L. brevirostris*	No. of Samples
April, *1957*	46.7	12.3	0.6	29.8	0.4	8.2	2.0	------	------	------	------	------	25
May	33.6	8.9	1.1	42.8	------	7.8	5.8	------	------	------	------	------	8
June	42.5	12.7	1.4	33.5	0.06	4.1	1.8	------	------	------	------	------	13
July	70.5	0.4	0.5	23.2	0.5	3.6	1.5	------	------	------	------	------	24
August	39.0	0.4	1.3	53.2	0.4	5.1	0.4	------	0.3	------	------	------	20
September	27.9	2.3	4.4	58.9	0.6	5.2	0.02	0.2	------	------	------	------	26
October	30.2	3.3	5.6	26.8	0.4	1.5	3.2	------	0.03	------	------	------	17
November	50.4	4.8	3.2	39.7	0.3	0.5	0.8	------	0.2	------	------	------	24
December	44.7	2.4	5.0	46.0	0.9	0.2	0.8	------	0.1	------	------	------	17
January, *1958*	44.2	5.0	1.5	46.2	1.	1.5	0.2	------	0.1	----	----	------	16
February	43.1	2.4	.	47.0	1	4.3	0.03	------	0.06	------	------	------	22
March	36.1	7.4	1.5	35.4	1.1	18.2	0.05	------	0.06	------	------	------	30
April	40.8	13.5	0.7	15.8	0.8	17.3	2.1	0.02	0.02	------	------	------	33
May	65.7	8.6	0.7	18.1	0.2	2.9	3.6	0.06	------	------	------	------	30
June	83.6	2.3	0.2	8.1	0.4	3.1	2.3	0.03	0.01	------	0.004	------	27
July	72.0	2.1	1.4	13.8	1.0	3.7	3.0	0.005	0.1	------	------	------	30
August	57.8	4.2	4.0	21.7	0.9	5.3	5.7	------	0.2	------	------	------	30
September	62.0	1.0	1.0	25.0	0.6	1.5	1.2	------	0.4	0.2	0.1	------	11
October	50.1	0.8	1.1	24.6	2.4	13.6	1.5	------	0.8	0.02	------	0.6	30
April, '57 to October, '58	52.2	5.0	1.9	32.4	0.71	5.7	1.9	0.006	0.13	0.01	0.006	0.003	433

TABLE 5.—*Shares of the species of Leiognathidae by numbers on the total catch of otter trawls (per cent)*

Month	*L. splendens*	*L. bindus*	*L. insidiator*	*L. ruconius*	*L. blochii*	*L. daura*	*L. lineolatus*	*L. equulus*	*Gazza minuta*	*Gazza achlamys*	*L. leuciscus*	*L. elongatus*	No. of samples
January, *1957*	35.0	17.7	10.0	------	------	31.5	5.5	------	0.6	------	------	------	27
February	18.3	40.0	38.0	1.7	0.72	0.04	0.3	1.1	0.09	------	------	------	29
March	23.0	62.5	6.6	5.9	0.83	------	0.7	------	0.07	------	------	------	16
April	12.6	77.5	5.5	3.0	0.09	------	1.2	0.09	0.04	------	------	------	33
May	7.4	83.5	7.3	0.52	0.08	------	1.3	0.14	0.01	------	------	------	28
June	41.0	8.2	33.4	12.8	1.2	0.01	3.1	0.6	------	------	------	------	25
July	45.5	34.0	2.5	11.7	1.67	0.9	0.52	2.9	0.02	------	------	------	27
August	34.6	25.0	21.0	9.5	3.1	0.03	3.2	3.2	0.7	------	------	------	28
September	55.0	6.3	30.0	7.1	0.43	------	1.05	0.07	.008	------	------	------	31
October	23.2	5.0	7.8	53.5	1.2	0.834	2.9	0.4	5.1	------	------	------	28
November	12.2	4.2	14.7	26.4	0.8	19.8	37.	0.4	17.7	------	------	------	24
December	21.3	5.3	7.8	64.4	0.08	------	0.3	0.09	------	------	------	------	27
January, *1958*	18.1	5.8	35.9	33.6	4.4	.08	------	2.0	------	------	------	------	33
February	7.0	13.7	63.4	13.7	1.2	.009	1.6	0.3	0.03	0.2	------	------	29
March	------	99.9	0.05	------	------	0.05	------	------	------	------	------	------	11
April	18.1	71.4	4.4	4.2	0.08	0.5	0.1	0.1	0.04	0.01	0.041	------	28
May	6.7	51.5	15.8	24.3	0.02	0.1	0.7	------	0.03	0.1	0.5	----	29
June	35.0	17.8	4.5	36.3	0.3	1.8	2.6	0.05	0.4	0.07	1.1	------	26
July	66.5	22.6	2.2	3.6	------	0.1	1.6	0.6	1.0	1.3	0.4	------	10
August	49.4	13.1	26.1	6.0	0.3	0.4	4.4	0.1	0.2	0.01	------	0.1	34
September	17.6	19.6	4.8	0.1	0.1	17.4	7.4	1.4	29.4	1.3	0.7	------	26
October	65.2	0.9	20.4	3.1	2.8	0.6	4.5	1.5	0.2	0.4	0.1	------	11
January 1957 to Oct. 1958	27.9	31.2	16.5		0.84	3.37	.12	0.68	2.53	0.15	0.13	0.004	560

in Manila Bay. The graphical representation of the catch shows that the share of *L. bindus* rapidly increased from about 20 to 80 per cent from January to May 1957 and dropped to about 5 per cent from September to January 1958, increasing again up to 99.9 per cent in March and representing the most abundant species until May 1958.

The case of *L. ruconius* is very different. The species was not at all represented in the January 1957 samples. The first records for the species were made in February. Its share increased then very slowly in the following months, reaching some 10 per cent from June to September, then 50 per cent to 60 per cent from October to December, in the two following months rapidly decreasing and again totally absent from the catch in March 1958. It was again represented in April becoming abundant in June 1958 but disappeared again the following months. The cycle of abundance for *L. ruconius* seems to be irregular and not bound to a yearly periodicity. Compared with these two species, the distribution of *L. splendens* appears more balanced. However, a characteristic development of the catch polygon can also be concluded here. This species was most abundant from June to September with percentage of about 40 per cent and more during both years. It had its minimum abundance from January to May.

The contribution of *L. insidiator* was much less than that of the three above-mentioned species in the catches, except in February 1958 when it was the dominant species caught, only to disappear again in the following month, appearing insignificantly later on. None of the other species was abundant enough during the period of survey to allow the recognition of predominant trends. Nevertheless, it is noteworthy to mention that *L. daura* and *Gazza minuta* were found in considerable quantities of some 20 per cent each in the samples during certain times. Apparently large schools of these species can enter the bay once in a while.

Summarized, the important conclusion can be reached that in the case of Leiognathidæ the trawl fishery depends on fish stocks which can spontaneously leave the fishing grounds and which are readily replaced by fish stocks of other species from time to time. This occurs in a cycle which may last longer or correspond with that of a biological year. The factors responsible cannot as yet be ascertained in their single phases until now. But it is likely that the factors causing the strong

fluctuations in the availability of slipmouth stocks to the otter trawl fishery in Manila Bay are found outside the bay waters and are strongly related to the spawning conditions of each species and the prevailing monsoon which may influence the movement of the young into the bay, inasmuch as these fish spawn outside the bay.

It is possible that this finding is typical for the situation of Philippine trawl fishery which is very limited in extent due to the lack of suitable trawling grounds offshore and, therefore, is closely bound to bay waters and other coastal areas. Under this aspect considerable fluctuations in the availability of the different fish stocks occur, which unfortunately cannot be followed up by tracing the movement of the stocks after they leave the coastal fishing grounds as is found possible in the fishery of the temperate zones which has extensive offshore trawling grounds. On the other hand, the fluctuations in the species availability of demersal fish stocks in tropical waters can be readily overlooked because of the large number of closely related species, so that fluctuations of abundance of each species are not readily recognized from the catch statistics alone.

It is known that the detailed sorting of the otter trawl catches by species is not possible in the commercial fishing operation because of the presence of about 100 different species representing more than 30 families of fish.(6) The catches are only roughly sorted into groups, namely:

(1) *Hoya*—first class fish (pomadasids, lutjanids, carangoids, groupers, etc.).
(2) *Halo*—second class fish (nemipterids, goatfishes).
(3) *Samot*—third class fish (mojarras, small hairtails).
(4) *Sapsap*—(slipmouths).
(5) *Kalaso*—(lizard fishes).
(6) *Hipon*—(shrimps).
(7) *Pusit*—(squids).

However, it appears that in the catch records being submitted to the Bureau of Fisheries only the following groups are used:

(1) *Hipon*—(shrimps).
(2) *Bisugo*—(nemipterids).
(3) *Kalaso*—(lizard fishes).
(4) *Sapsap*—(slipmouths).
(5) miscellaneous.

It is obvious that such catch records cannot satisfy the requirements of biological research which need more accurate data if yearly fluctuations in the landing and in fish stocks

are to be determined to establish definite relationship between the yield of the fishery on one hand, and the fishing intensity and dynamics of fish stocks on the other.

Seasonal length composition of catches.—The monthly length composition of each species caught by different gears are compared and discussed in the following:

Leiognathus splendens.

A large material of length frequency data was collected for each of the three gears. The number of specimens on which each length-frequency curve is based, may be seen (n) beside each curve. Figure 4 clearly shows the relation between the age groups of *L. splendens* caught by the different gears. A predominant cycle in the availability of various age groups to the different gears becomes obvious. In April and May of 1957–1958, the beginning of the SW monsoon season and the end of the fish corral season, young fish stocks appeared in the coastal parts of the bay, and replaced the dominant age groups of previous months in this area. Up to October, the beginning of the NE monsoon season and of the fish corral season, they grew from 25 mm. to about 45 mm. In the following months, this age group was available to both the fish corrals and the baby trawls. During the same period, the otter trawl fishery depended upon the older age groups. At the latter part of the fish corral season in about March–April, the age group being utilized by the fish corrals and baby trawls then became partly available to the otter trawls which until then had been utilizing an age group which has not been available to the fish corral at all. This is possible since it can be concluded that the age group found in the otter trawls from July 1957 to February 1958 can be easily traced back as a second predominant young age group, which entered the baby trawl fishery in April, 1957 and was found in the otter trawl catch in April 1958 near the mouth of Manila Bay at 24 fathoms. The average size of this age group was about 40 mm. long during April and May 1957 representing the main catch of the baby trawl, although most likely it had already left the shallow parts of the Bay in June and become the main age group available to the otter trawls from July up to April 1958. During one year's time the age group reached a length of about 85 mm. (length increase, some 45 mm.). Since the yearly increase in length for the smallest age group (25 mm.) in May 1957 was calculated to be 50 mm. (75 mm. in May 1958), it is likely that both young age groups represented in the baby trawl catches in May, 1957 are not separated by one year, but by a smaller age difference. These age groups belong to different spawning classes which are probably 4 to 6 months apart. The fact that both age groups enter Manila Bay at the same time and do not primarily enter the bay at the same age may be explained by the prevailing monsoon seasons. It is very probable that the NE monsoon prevented the older of the two young age groups to enter the bay earlier, namely, before the beginning of the SW monsoon season.

The question was checked if the larger length frequencies found in the otter trawl catches may be caused by factors originating in a different selectivity of the gear or if real differences in the distribution of age

groups with regard to fishing areas can be concluded, as believed. Although fig. 4 answers this question in previous months, as in a few months back, small specimens formed also the main catch of the otter trawl fishery, a checking became necessary in those months when small *L. splendens* were wanting in the otter trawl fishery. The significance of results can easily be tested by looking at figures 6, 7, 8 where length frequencies of smaller specimens of other *Leiognathus* species which were caught at the same time are given.

Nevertheless, it became desirable to compare the selectivity of the different mesh sizes used in otter trawls and in our baby trawls. As reported above, mesh sizes of $1\frac{1}{4}$ inches were found in the bag of otter trawl nets while our standard net had mesh sizes of $\frac{3}{4}$ inch in its bag.

A series of other nets with larger mesh sizes was made and their catches compared with the standard net. The results of this investigation which shall be separately reported clearly indicate that, although differences in the yield were found, no characteristic differences in the length frequencies of catches were found between nets of $\frac{3}{4}$ and $1\frac{1}{4}$ inch in their bag as shown by fig. 5 in which size frequencies of *L. splendens* caught with the two different mesh sizes are compared.(5)

Leiognathus bindus.

L. bindus represents a species with a distinct seasonal character contrary to *L. splendens*. It has its main abundance in February to August in the deeper parts and from March to June in the shallower parts of Manila Bay. During the months from July, 1957, to February, 1958, its share on the *Leiognathus* catches was less than 3–5 per cent in the shallower parts and from September, 1957, to January, 1958, less than about 7 per cent in the deeper parts, the fishing area of otter trawlers (compare tables 4 and 5).

L. bindus was more common in the deeper part of the bay than in the shallower. While relatively more *L. splendens* was found in the baby trawl catch as seen in Table 4, *L. bindus* was normally much more abundant in the deeper parts of the bay (Table 5) throughout the whole research period. The unequal availability of *L. bindus* in the research areas is shown by (n) alongside the length frequencies for each month (fig. 6). Although the average length of specimens is also considerably smaller in the shallower parts than in the deeper parts of the bay in most of the months, the separation of age groups is less distinct due to numerous age groups entering the fishery.

It may be noted from fig. 6 that while *L. bindus* was the more common species caught by the otter trawl from February to May due to the presence of older fish in the area these fish were probably in their spawning migration and therefore disappeared from the fishery in later months. In June a new age group, again on its way to spawn outside Manila Bay, entered the otter trawl fishery until August. In the meanwhile, a smaller age group available to the baby trawl fishery in May became available to the otter trawls in the succeeding months. Likewise, new age groups entered the baby trawl fishery in June and September, 1957 and several times more during the research period.

A yearly length increase of 45 mm. is likely for *L. bindus*. The recruitment of *L. bindus* in Manila Bay is more frequent than that of

L. splendens. The recruits enter the baby trawl fishery only in a limited extent and become available to the otter trawlers very soon after their movement into the bay. This is probably due to the preference of this species for the intermediate zone which is out of the normal fishing range of baby trawls and fish corrals.

Leiognathus insidiator.

Similar to *L. bindus*, *L. insidiator* can be considered as a species of the deeper waters. Its share on the catches of *Leiognathidæ* was several times greater in deeper water than in the baby trawls area (Tables 4 and 5). Specimens from the baby trawl as well as the otter trawl areas did not differ much in their length compositions except for the occasional observation of younger strong age groups entering the baby trawl fishery, notably in June and October, 1957, and March, and July, 1958 (fig. 7).

Leiognathus ruconius.

From April to September, 1957, *L. ruconius* was much more abundant in the baby trawl area than in the deeper waters. From October to December, 1957, however, suddenly it was the most abundant species of slipmouth in the otter trawl fishery. During this time a very strong age group, which was found for the first time in June, 1957, in the baby trawl catches (32 mm.) had reached a length of some 46 mm., and apparently started to migrate to the deeper waters and became available to the otter trawl fishery from December to July, 1958 showing an average length of 62 mm. (fig. 8). The observed difference in the size composition of specimens caught in both areas is not as distinct as in *L. splendens.* The specimens caught in otter trawls were more or less uniform in size (fig. 8).

Leiognathus daura.

L. daura was mainly caught by the baby trawls. During the research period it was represented in considerable number in the otter trawl catches only in January and November, 1957, and September, 1958 (Table 5). As fig. 9 shows, it is likely that during these months the stock (50-60 mm. length) which inhabited the shallower parts of Manila Bay since May, 1957, moved to the deeper portion of the bay, then 70-80 mm. long, and in their spawning migration, became partly available to the otter trawls.

Leiognathus lineolatus.

L. lineolatus was caught by both gears in nearly equal ratios although the species could not reach any large share on the total catch of slipmouths, namely, only about 6 per cent at most during the period of research. Except during the months of September to December, 1957, the length composition differs widely. Here again the younger age groups were found in the shallower parts while the older were in the deeper parts of the bay (fig. 10).

Although the length frequency curves are widely distributed in both the baby trawl and otter trawl samples, inspection of some peaks reveals a characteristic curve indicating a growth rate of 44 mm. in a year.

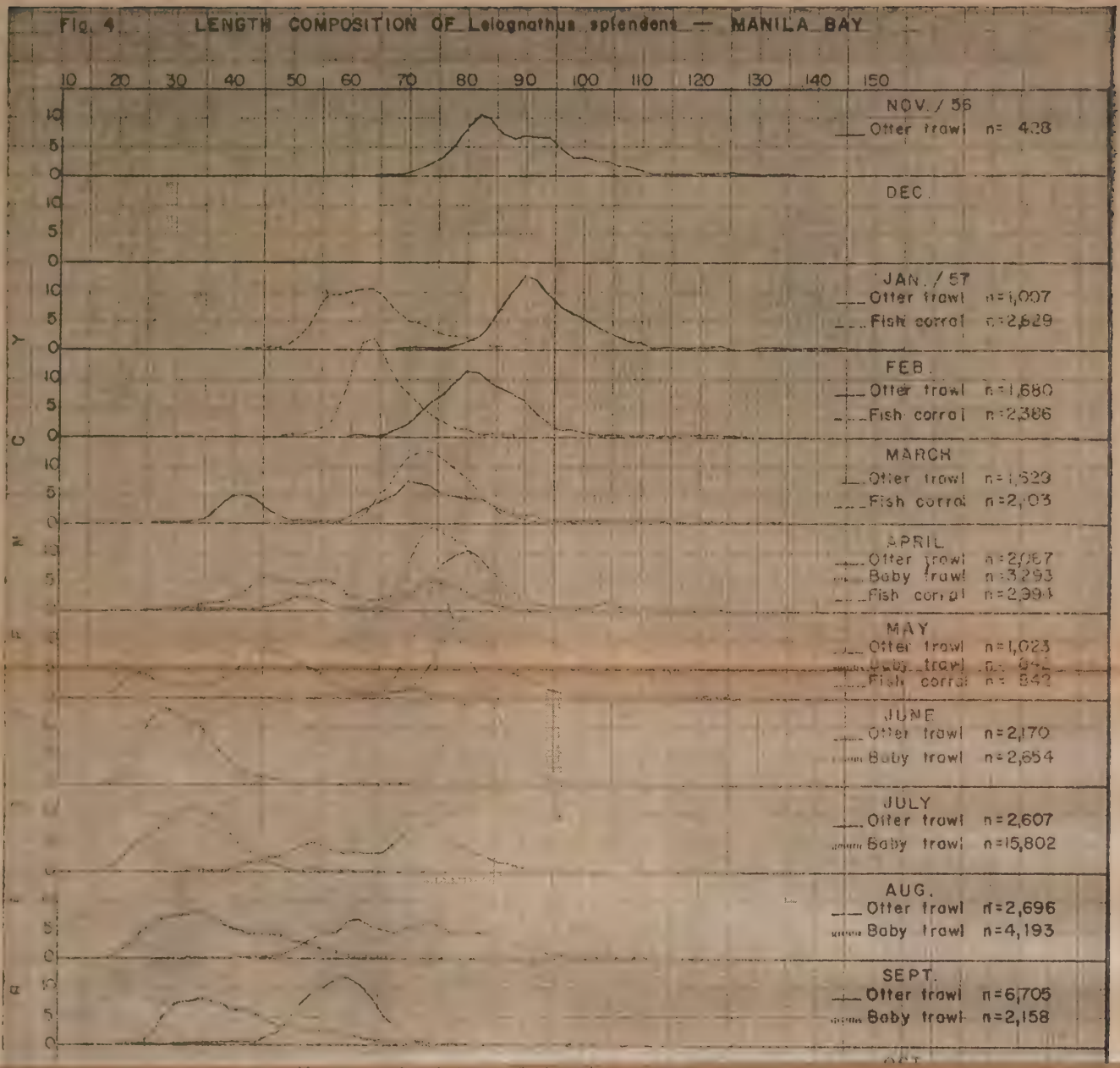


Fig. 4 LENGTH COMPOSITION OF Leiognathus splendens — MANILA BAY
10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
NOV. / 56
Otter trawl n= 428
DEC.
JAN. / 57
Otter trawl n=1,007
Fish corral n=2,629
FEB.
Otter trawl n=1,680
Fish corral n=2,386
MARCH
Otter trawl n=1,529
Fish corral n=2,103
APRIL
Otter trawl n=2,067
Baby trawl n=3,293
Fish corral n=2,394
MAY
Otter trawl n=1,023
Fish corral n= 842
JUNE
Otter trawl n=2,170
Baby trawl n=2,654
JULY
Otter trawl n=2,607
Baby trawl n=15,802
AUG.
Otter trawl n=2,696
Baby trawl n=4,193
SEPT.
Otter trawl n=6,705
Baby trawl n=2,158

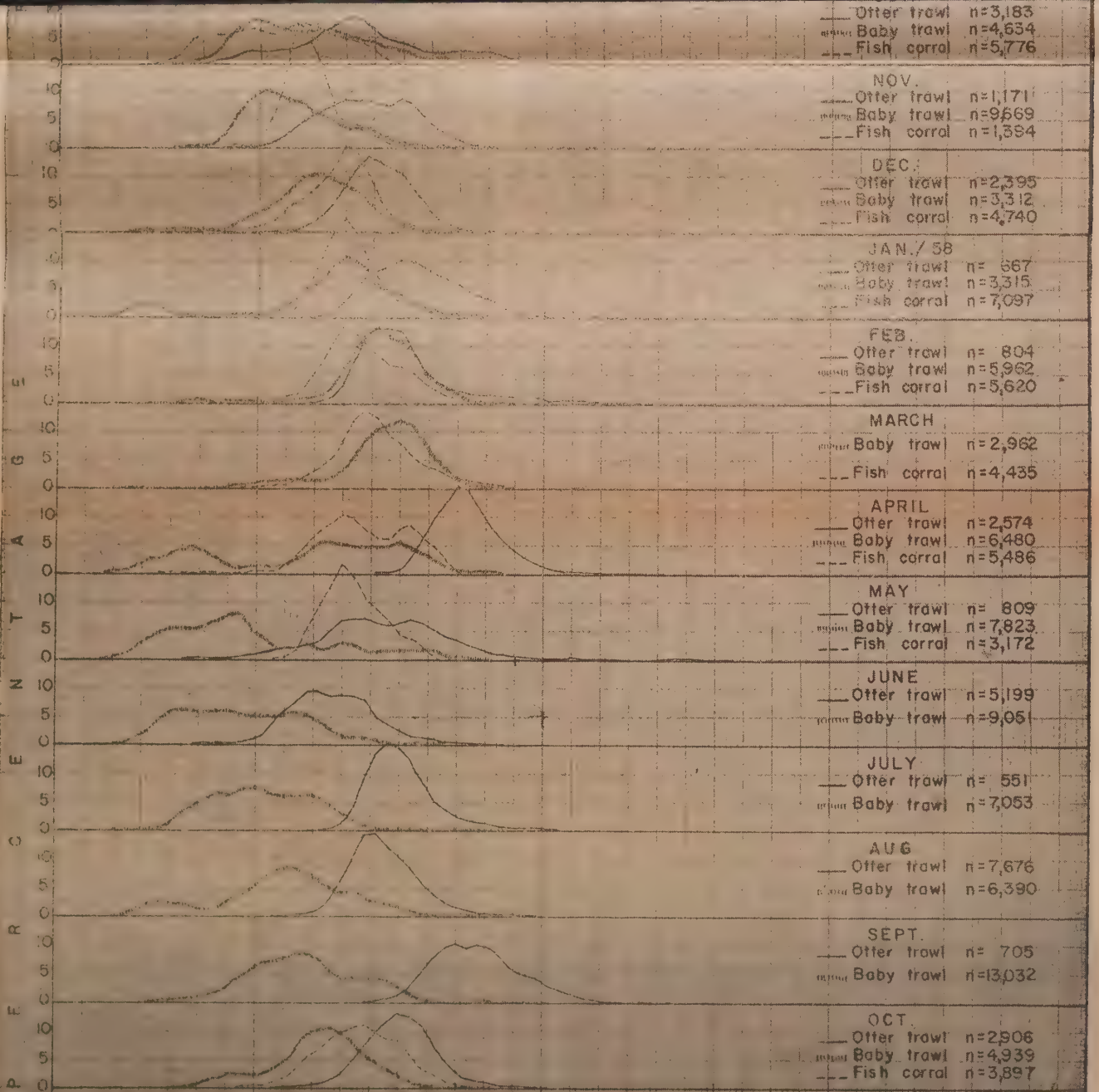
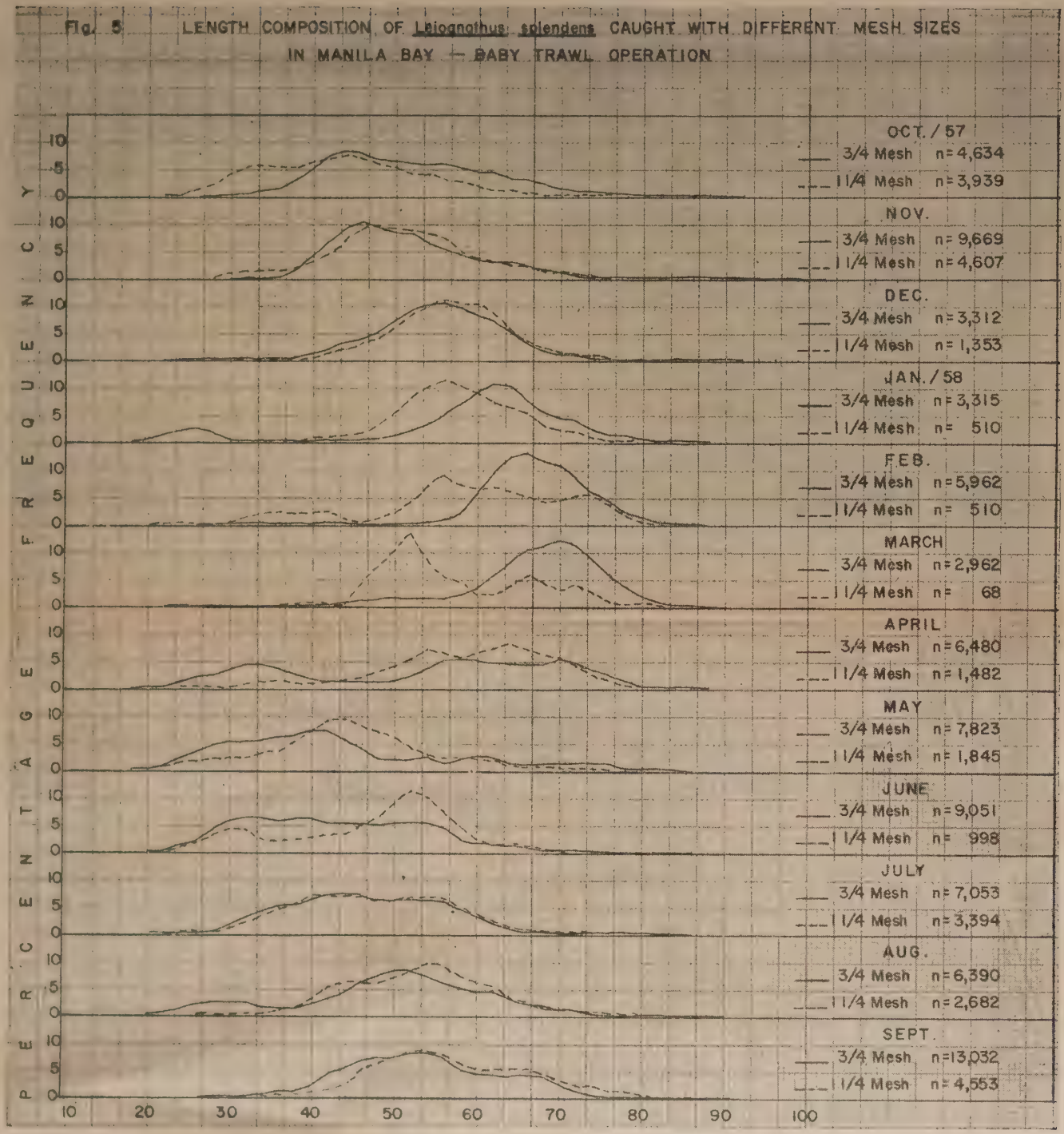

PERCENTAGE
Otter trawl n=3,183
Baby trawl n=4,634
Fish corral n=5,776
NOV.
Otter trawl n=1,171
Baby trawl n=9,669
Fish corral n=1,384
DEC.
Otter trawl n=2,395
Baby trawl n=3,312
Fish corral n=4,740
JAN./58
Otter trawl n= 667
Baby trawl n=3,315
Fish corral n=7,097
FEB.
Otter trawl n= 804
Baby trawl n=5,962
Fish corral n=5,620
MARCH
Baby trawl n=2,962
Fish corral n=4,435
APRIL
Otter trawl n=2,574
Baby trawl n=6,480
Fish corral n=5,486
MAY
Otter trawl n= 809
Baby trawl n=7,823
Fish corral n=3,172
JUNE
Otter trawl n=5,199
Baby trawl n=9,051
JULY
Otter trawl n= 551
Baby trawl n=7,053
AUG
Otter trawl n=7,676
Baby trawl n=6,390
SEPT.
Otter trawl n= 705
Baby trawl n=13,032
OCT.
Otter trawl n=2,906
Baby trawl n=4,939
Fish corral n=3,897

Fig. 5 LENGTH COMPOSITION OF *Leiognathus splendens* CAUGHT WITH DIFFERENT MESH SIZES IN MANILA BAY — BABY TRAWL OPERATION



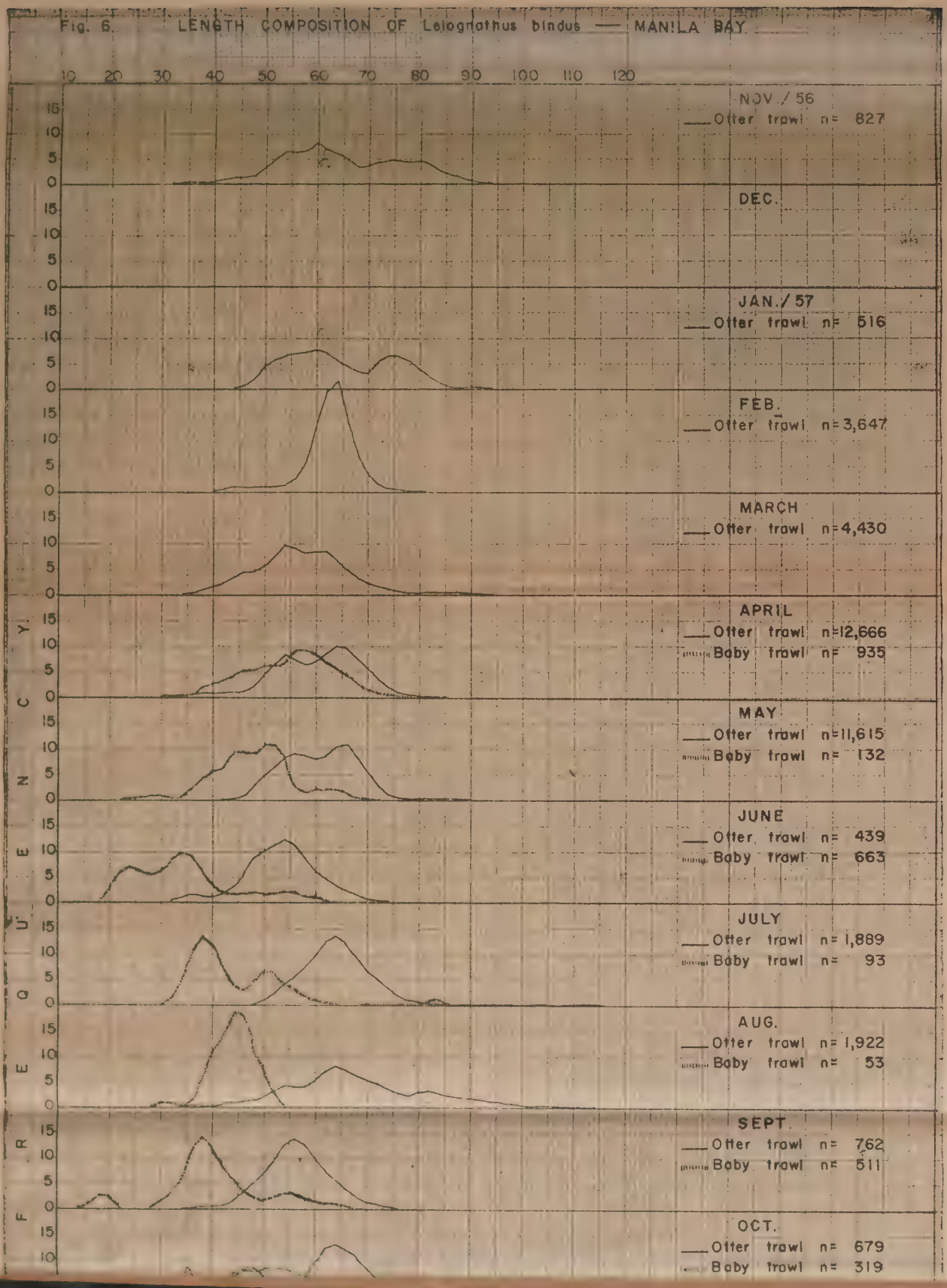


Fig. 6. LENGTH COMPOSITION OF Leiognathus bindus — MANILA BAY
10 20 30 40 50 60 70 80 90 100 110 120
FREQUENCY
NOV./56
Otter trawl n= 827
DEC.
JAN./57
Otter trawl n= 516
FEB.
Otter trawl n=3,647
MARCH
Otter trawl n=4,430
APRIL
Otter trawl n=12,666
Baby trawl n= 935
MAY
Otter trawl n=11,615
Baby trawl n= 132
JUNE
Otter trawl n= 439
Baby trawl n= 663
JULY
Otter trawl n= 1,889
Baby trawl n= 93
AUG.
Otter trawl n= 1,922
Baby trawl n= 53
SEPT.
Otter trawl n= 762
Baby trawl n= 511
OCT.
Otter trawl n= 679
Baby trawl n= 319

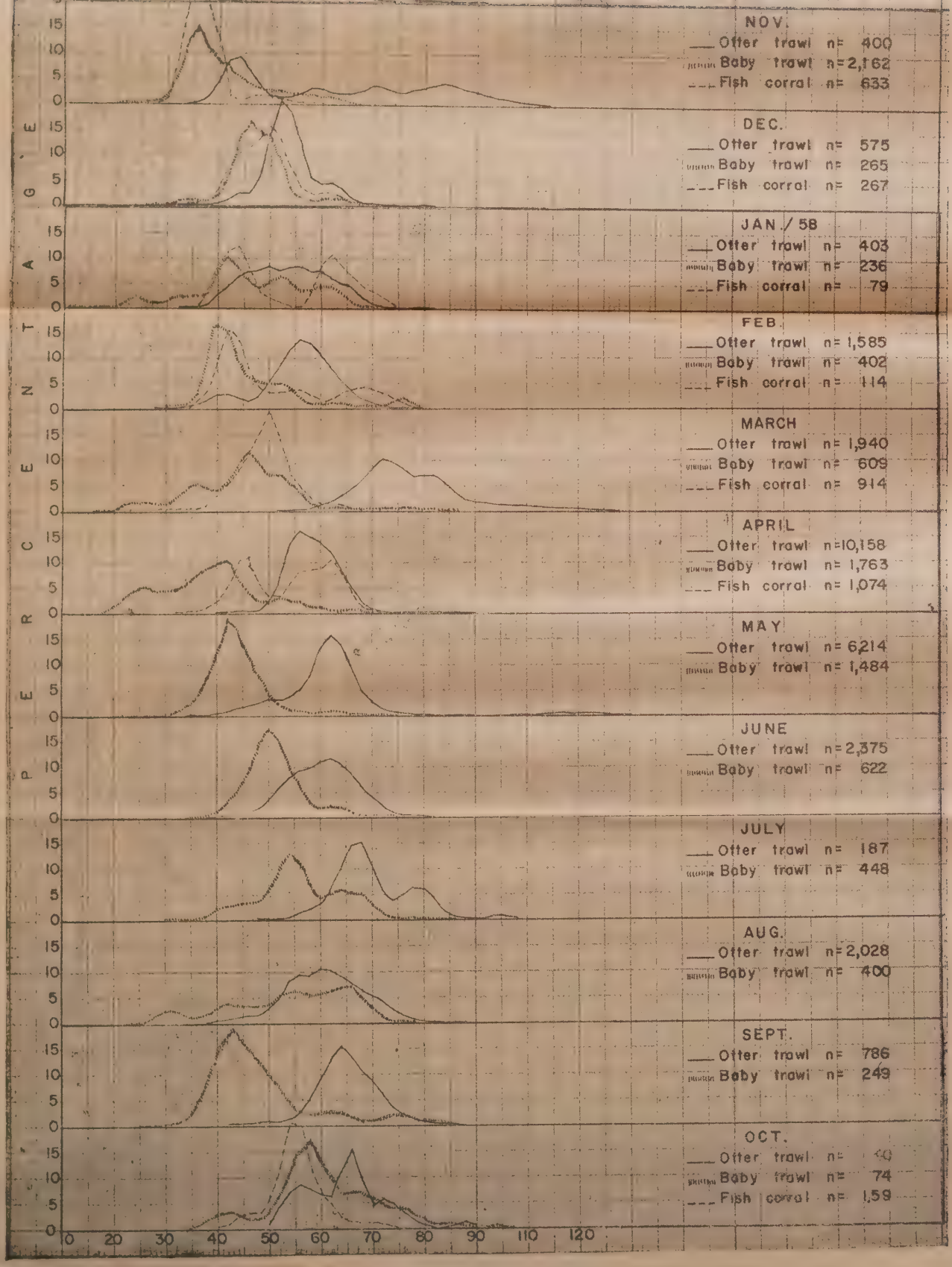
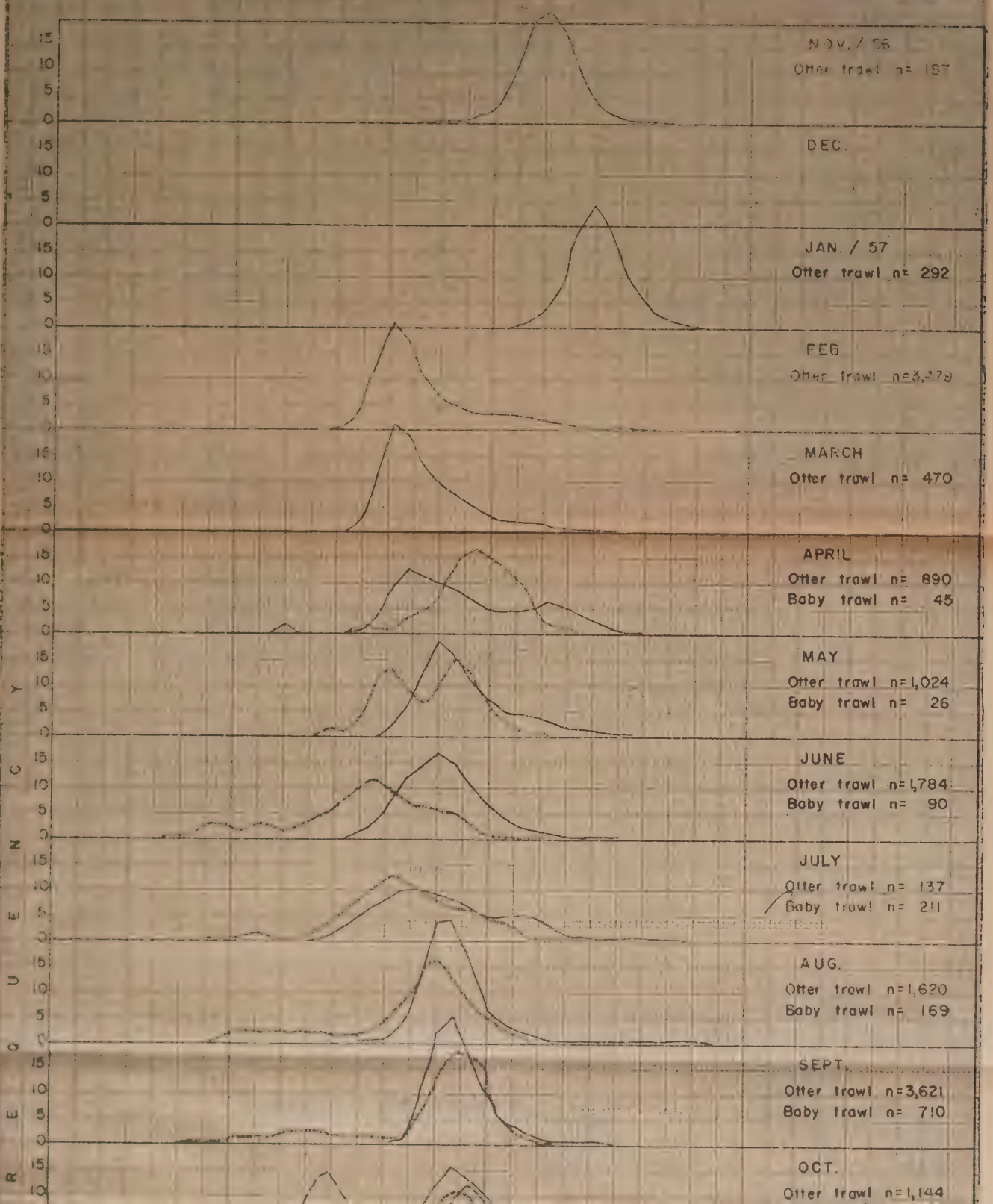
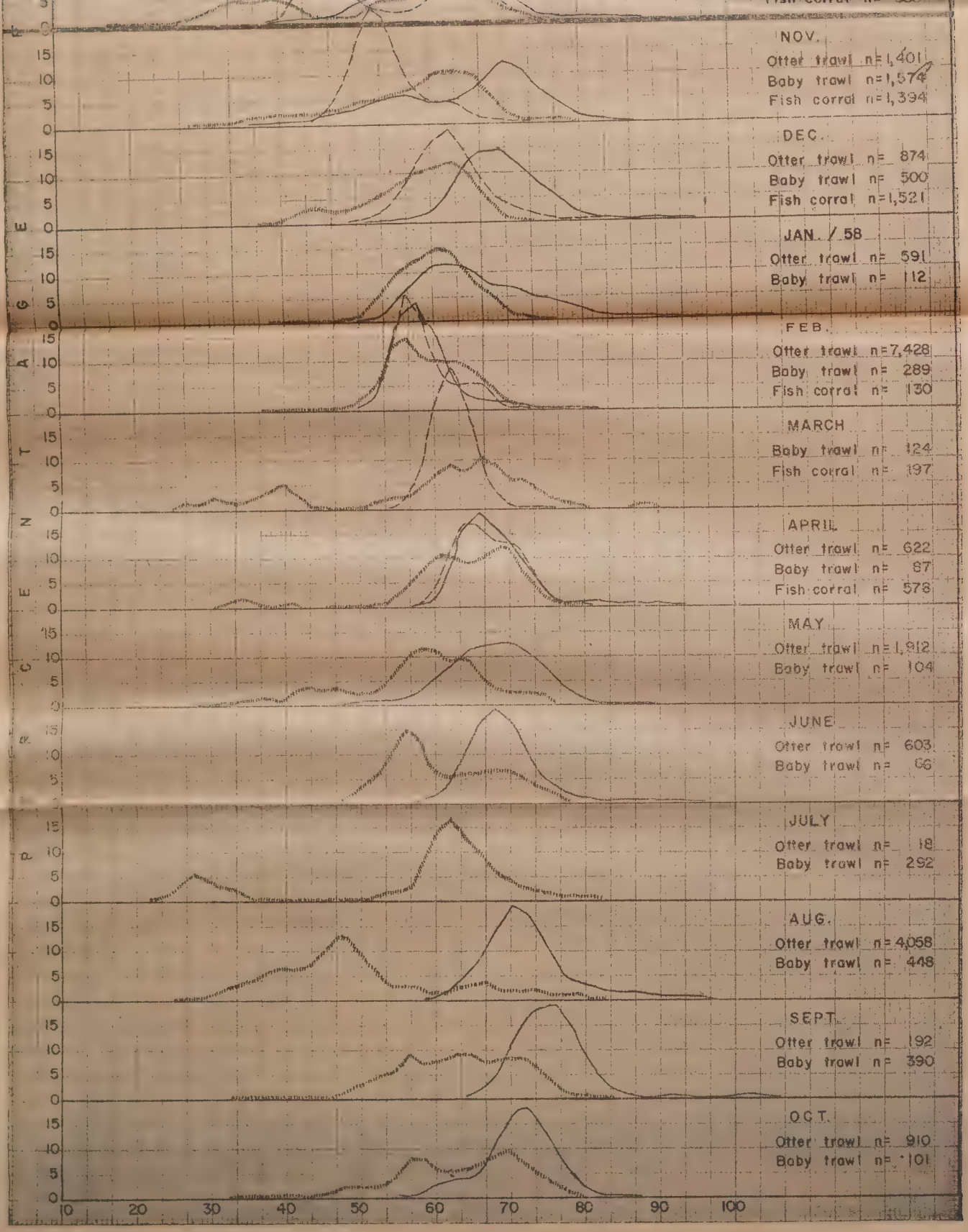

PERCENTAGE
NOV.
Otter trawl n= 400
Baby trawl n=2,162
Fish corral n= 633
DEC.
Otter trawl n= 575
Baby trawl n= 265
Fish corral n= 267
JAN./58
Otter trawl n= 403
Baby trawl n= 236
Fish corral n= 79
FEB.
Otter trawl n=1,585
Baby trawl n= 402
Fish corral n= 114
MARCH
Otter trawl n=1,940
Baby trawl n= 609
Fish corral n= 914
APRIL
Otter trawl n=10,158
Baby trawl n=1,763
Fish corral n=1,074
MAY
Otter trawl n=6,214
Baby trawl n=1,484
JUNE
Otter trawl n=2,375
Baby trawl n= 622
JULY
Otter trawl n= 187
Baby trawl n= 448
AUG.
Otter trawl n=2,028
Baby trawl n= 400
SEPT.
Otter trawl n= 786
Baby trawl n= 249
OCT.
Otter trawl n= 40
Baby trawl n= 74
Fish corral n= 159
0 10 15
0 5 10 15
0 10 20 30 40 50 60 70 80 90 110 120

Fig. 7 LENGTH COMPOSITION OF Leiognathus insidiator — MANILA BAY




PERCENTAGE
NOV.
Otter trawl n=1,401
Baby trawl n=1,574
Fish corral n=1,394
DEC.
Otter trawl n= 874
Baby trawl n= 500
Fish corral n=1,521
JAN. / 58
Otter trawl n= 591
Baby trawl n= 112
FEB.
Otter trawl n=7,428
Baby trawl n= 289
Fish corral n= 130
MARCH
Baby trawl n= 124
Fish corral n= 197
APRIL
Otter trawl n= 622
Baby trawl n= 87
Fish corral n= 578
MAY
Otter trawl n=1,912
Baby trawl n= 104
JUNE
Otter trawl n= 603
Baby trawl n= 66
JULY
Otter trawl n= 18
Baby trawl n= 292
AUG.
Otter trawl n=4,058
Baby trawl n= 448
SEPT.
Otter trawl n= 192
Baby trawl n= 390
OCT.
Otter trawl n= 910
Baby trawl n= 101
0
5
10
15
10
20
30
40
50
60
70
80
90
100

This may be shown by a weak age group (40 mm.) in April, 1957, which became the dominant age group caught by the baby trawls in the succeeding months contributing to the catch of both baby trawl and otter trawl from September to December and finally becoming the dominant catch (84 mm.) of the latter during April and May, 1958, just before disappearing from the fishery probably on their spawning migration outside the bay.

Other species.

L. equulus is a fish of the deeper water. The species was found in baby trawl catches only in September, 1957 (0.02 per cent), April, 1958 (0.02 per cent) and in May, 1958 (0.06 per cent). The length frequencies of this species are given in fig. 11. *Gazza minuta* was scarcely represented in the catches of both sampling gears. However, in October and November, 1957, its share exceeded 1 per cent (5.1 per cent and 17.7 per cent) in the otter trawl operation (Table 5). The length composition of catches is given in fig. 10.

Length composition of catches in relation to depth of fishing grounds in deeper water.—As could be shown above, the length composition of most of the slipmouth species inhabiting both areas differ. The baby trawl area is from 2 to 8 fathoms and the otter trawl area is from some 10 to 25 fathoms. The collected materials indicate that the younger smaller fish generally prefer to stay in the shallower waters. Several months after their first appearance they normally leave this area, having considerably grown in the meanwhile, in order to migrate to the deeper parts of the bay. The leaving stock is normally replaced by a new and younger fish stock, as could be clearly shown in the case of *L. splendens*, *L. ruconius*, *L. daura*, and *L. lineolatus*. The cycle of first arrival in the shallower waters and migration from the bay approximately extends over one year in *L. splendens*. *L. daura* and *L. lineolatus* and may be shorter in *L. bindus*. *L. ruconius* and *L. insidiator*.

The original plan to divide the research area in more subareas had to be dropped since no adequate research vessel was available with which to systematically survey zones of different depth. This kind of survey was only possible with regard to the baby trawl fishing in the shallower area. However, the collected materials do not indicate any characteristic differences in the size composition of catches, since the selected depth zones of 2, 5 and later 8 fathoms are too close to each other to really allow any distinct formations of age groups, and since it is obvious that the fishes caught in this area in most cases represent one age group only.

Although the survey of the deeper parts of the bay was carried out aboard otter trawlers, it was at least in some months

possible to correlate different depths in the trawling grounds with regard to the length composition of catches. The results are given in Table 6 in which the average lengths of samples are compiled. They indicate that generally no characteristic difference was found in the length composition of slipmouth species living in different depths. This should not be wondered at since the whole fishery obviously depends on one or two age groups only. In very few cases, where the catch was composed of 2 age groups which can be roughly recognized by two peaks in the curves of length frequencies, the older one was normally found in the deeper waters as in the case of *L. splendens* in April and May, 1957.

TABLE 6.—*Average size of Leiognathus species caught from different depths in Manila Bay (in mm.).*

Species	10–15 Fathoms	15–20 Fathoms	20–25 Fathoms
L. splendens	71.7	78.1	82.8
L. bindus	58.8	62.7	65.6
L. fuconius	58.4	60.6	54.6
L. insidiator	66.8	70.2	71.7
L. lineolatus	78.6	81.4	83.6

POPULATION AS FOUND IN AND OUTSIDE THE SAN MIGUEL BAY

As reported under "Material", a smaller sampling program was carried out in San Miguel Bay on the Pacific coast of southern Luzon (fig. 12). Sampling was done during July 1957, October 1957, February 1958, and May 1958. It was possible to secure samples of the catches of the otter trawl fishery not only from inside but also from outside the bay. Extensive trawling grounds outside the bay are available in this area contrary to conditions in Manila Bay where technical difficulties make it impossible for the time being to travel outside the Bay due to the sudden changes in depth and the uneven contours of the bottom.

Catch composition and its seasonal changes.—The weight share of slipmouth based on the total catch was found to be larger outside the San Miguel Bay than inside the bay except in October when the condition was reversed (Table 7).

The share by number of each species on the total catch of slipmouths in otter trawls was found to be at variance during the whole period of research in and outside the bay (Table 8).

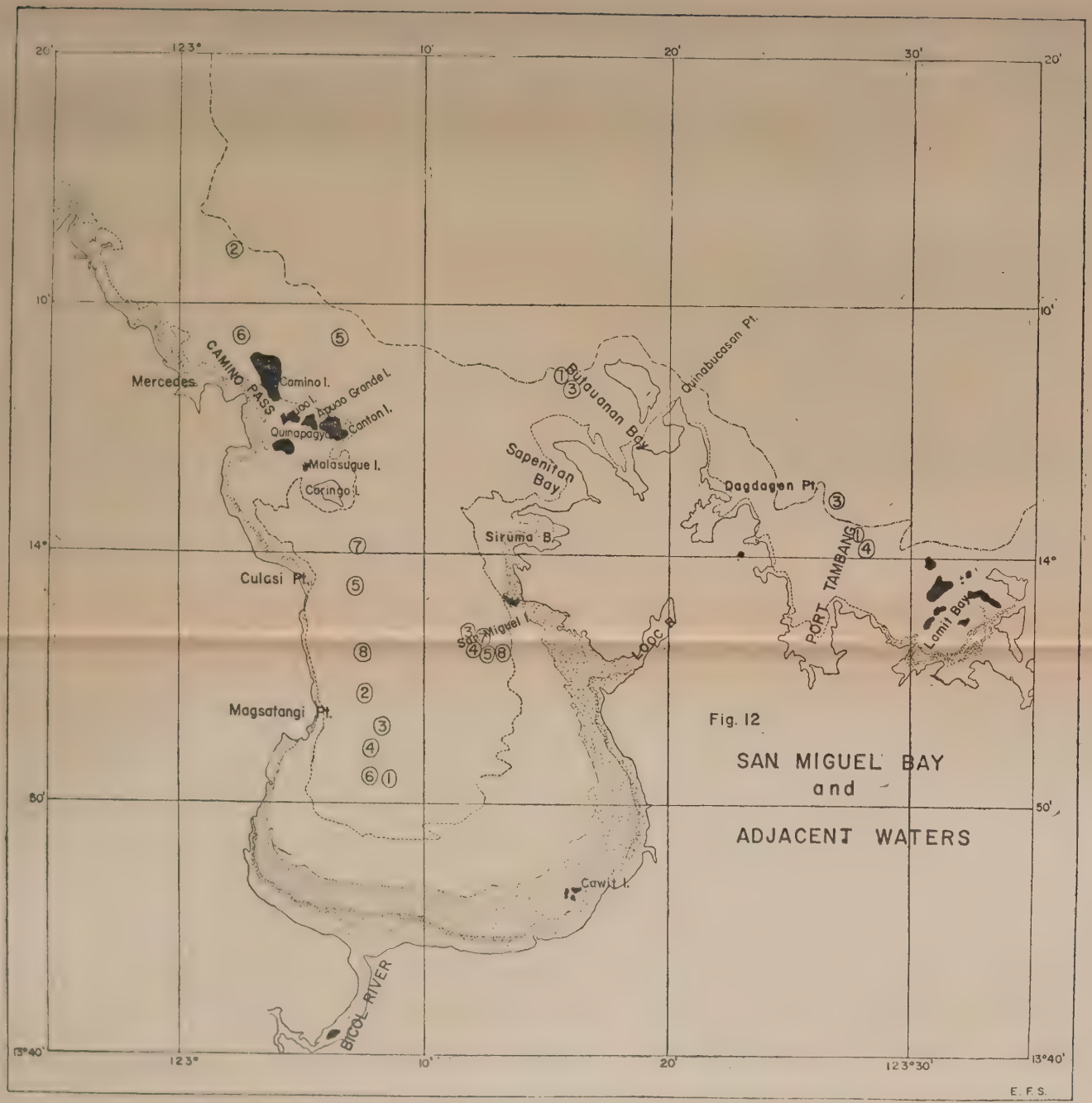


Fig. 12

SAN MIGUEL BAY
and
ADJACENT WATERS

TABLE 7.—*Weight shares of slipmouths on the total catch of otter trawlers in and outside San Miguel Bay (per cent)*

Month	No. of hauls	Wt. share	No. of hauls	Wt. share
		Per cent		*Per cent*
July, 1957	11	13.00	7	30.21
October	9	86.22	18	48.13
February '58	27	25.00	3	41.75
May	29	7.9	7	11.81

TABLE 8.—*Share of the different species on the total catch of slipmouths by number in otter trawls in San Miguel Bay (per cent)*

Species	July		October		February		May	
	Inside	Outside	Inside	Outside	Inside	Outside	Inside	Outside
L. splendens	8.6	37.1	41.1	32.8	5.0	34.2	0.5	51.8
L. bindus	47.2	9.5	14.7	13.1	41.1	43.4	44.2	32.4
L. insidiator	1.3	5.5	0.2	7.4	1.6	2.9	0.1	1.5
L. ruconius	22.8	0	42.5	24.2	21.2	9.6	46.4	3.9
L. leuciscus	0	0	0	0.06	0	0.4	0	0.2
L. blochii	8.1	0	0.3	0	0.7	0	1.0	0.004
L. dussumieri	0	0	0	11.8	0.07	4.5	3.8	1.6
L. equulus	0.2	4.5	0.03	1.8	0	1.8	0.1	0.3
L. fasciatus	0	39.4	0	0.06	0.02	0.4	0.2	0
G. minuta	11.7	4.2	1.1	8.8	0.4	2.7	1.1	7.4
G. achlamys	0	0	0	0.06	0.02	0.2	2.5	0.7
No. of samples	1	1	4	3	4	4	3	5
No. of specimens	1,600	381	13,611	3,194	4,541	3,576	3,853	4,968

Except for *L. dorra and L. lineolatus* which were found only in Manila Bay and *L. leuciscus*, *L. dussumieri* and *L. fasciatus* only found in San Miguel Bay, all other species were common to both areas.

Table 8 indicates that *L. insidiator*, *L. leuciscus*, *L. dussumieri*, *L. equulus*, *L. fasciatus*, *Gazza achlamys*, and, to a limited extent *G. minuta* were mainly caught outside the bay. However, *L. blochii* was only caught inside the bay, while *L. ruconius* although caught in large numbers outside the bay was more abundant inside. *L. bindus* was equally abundant in both areas except in July, 1957, when only one sample from each of the two areas was secured, while *L. splendens* was normally found to be strongly represented outside the bay.

The seasonal cycle in the abundance of the three common species in Manila Bay, namely, *L. bindus*, *L. ruconius* and *L. splendens*, is likely true also for the San Miguel Bay area (Table 9) in which the percentage share on the total catch for these species as calculated in both areas were compared.

Length compositions of catches in and outside the San Miguel Bay.—Fig. 13 to 16 show the length frequencies of

slipmouth species as found in and outside the San Miguel Bay. For the three most abundant species, *L. splendens, L. bindus* and *L. ruconius,* the larger fish were found only outside the bay.

Outside San Miguel Bay, fish were observed at size groups which were not found in Manila Bay, not even in the deeper parts of the bay. Our conclusions that these fish migrate out side the Manila Bay after having obtained certain size could be indirectly confirmed through the results obtained in San Miguel Bay area, where trawling outside the bay is possible.

TABLE 9.—*Comparison of percentage shares on the total catch of L. bindus, L. ruconius and L. splendens as calculated from the material collected in Manila Bay and inside the San Miguel Bay (compare Table 5 and 8).*

Month	Manila Bay	San Miguel Bay	Manila Bay	San Miguel Bay	Manila Bay	San Miguel Bay
July, 1957	34.0	47.2	11.7	22.8	45.5	8.6
October, 1957	5.0	14.7	53.5	42.5	23.2	41.1
February, 1958	13.7	41.1	13.7	21.2	7.0	5.0
May, 1958	51.5	44.2	24.3	46.4	6.7	0.3

ABSOLUTE ABUNDANCE OF SLIPMOUTHS IN THE COASTAL PARTS OF MANILA BAY

Table 10 shows the absolute abundance of slipmouth species based on baby trawl catches. The average numbers of specimens of each species were calculated from the normal dragging time of 30 minutes using a standard net of ¾ inch in the cod end. Roughly estimated 4,000 m² of bottom was covered during each haul.

It will be seen that *L. splendens* and *L. ruconius* are the most common species during the whole period of study. *L. splendens* is definitely the most numerous species represented in the shallower part of the bay except in a few instances. *L. bindus* and *L. daura* are next in rank, but can in no way compare with the first two species. The other species contribute very little to the catch.

RESOURCES AND FISHERY

The slipmouth fishery, though composed mostly of small-sized fish, is among the most important groups of commercial fishes mainly because of its abundance.(5) All over the shallower areas of the Philippines, slipmouths are fished in great

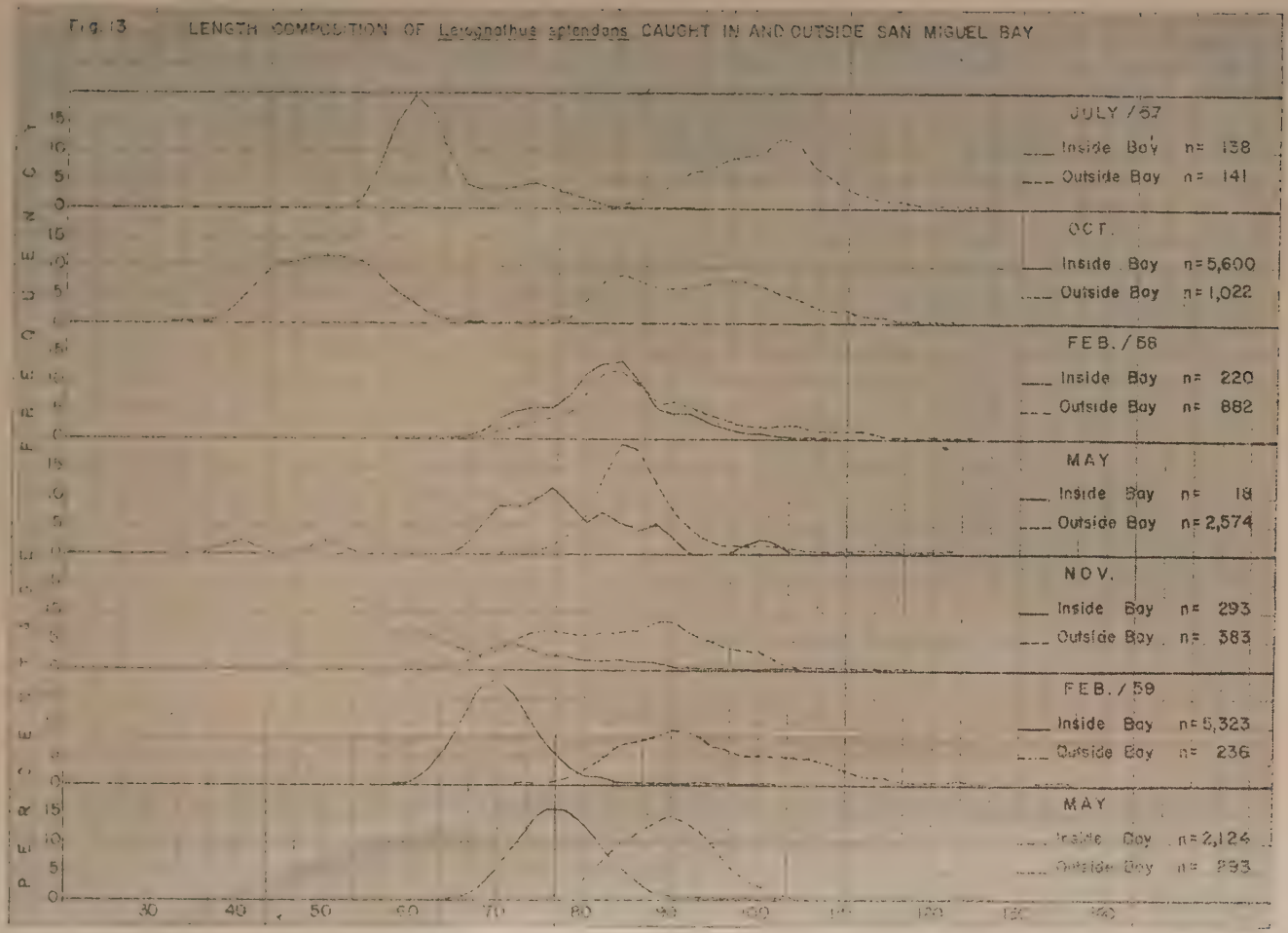


Fig. 13 LENGTH COMPOSITION OF Leiognathus splendens CAUGHT IN AND OUTSIDE SAN MIGUEL BAY
JULY / 57
Inside Bay n= 138
Outside Bay n= 141
OCT.
Inside Bay n=5,600
Outside Bay n=1,022
FEB. / 58
Inside Bay n= 220
Outside Bay n= 882
MAY
Inside Bay n= 18
Outside Bay n=2,574
NOV.
Inside Bay n= 293
Outside Bay n= 383
FEB. / 59
Inside Bay n=5,323
Outside Bay n= 236
MAY
Inside Bay n=2,124
Outside Bay n= 233
30
40
50
70
80

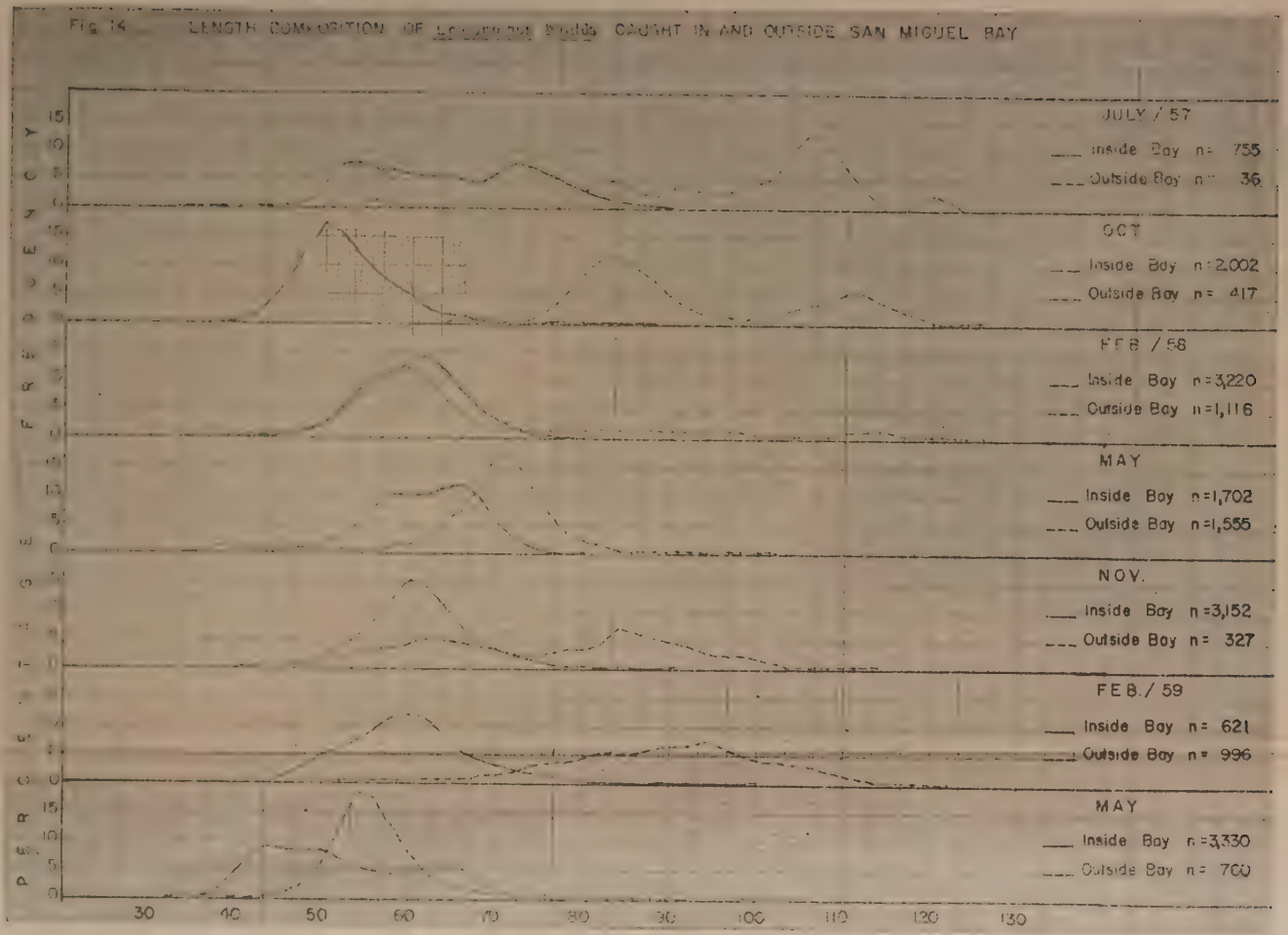
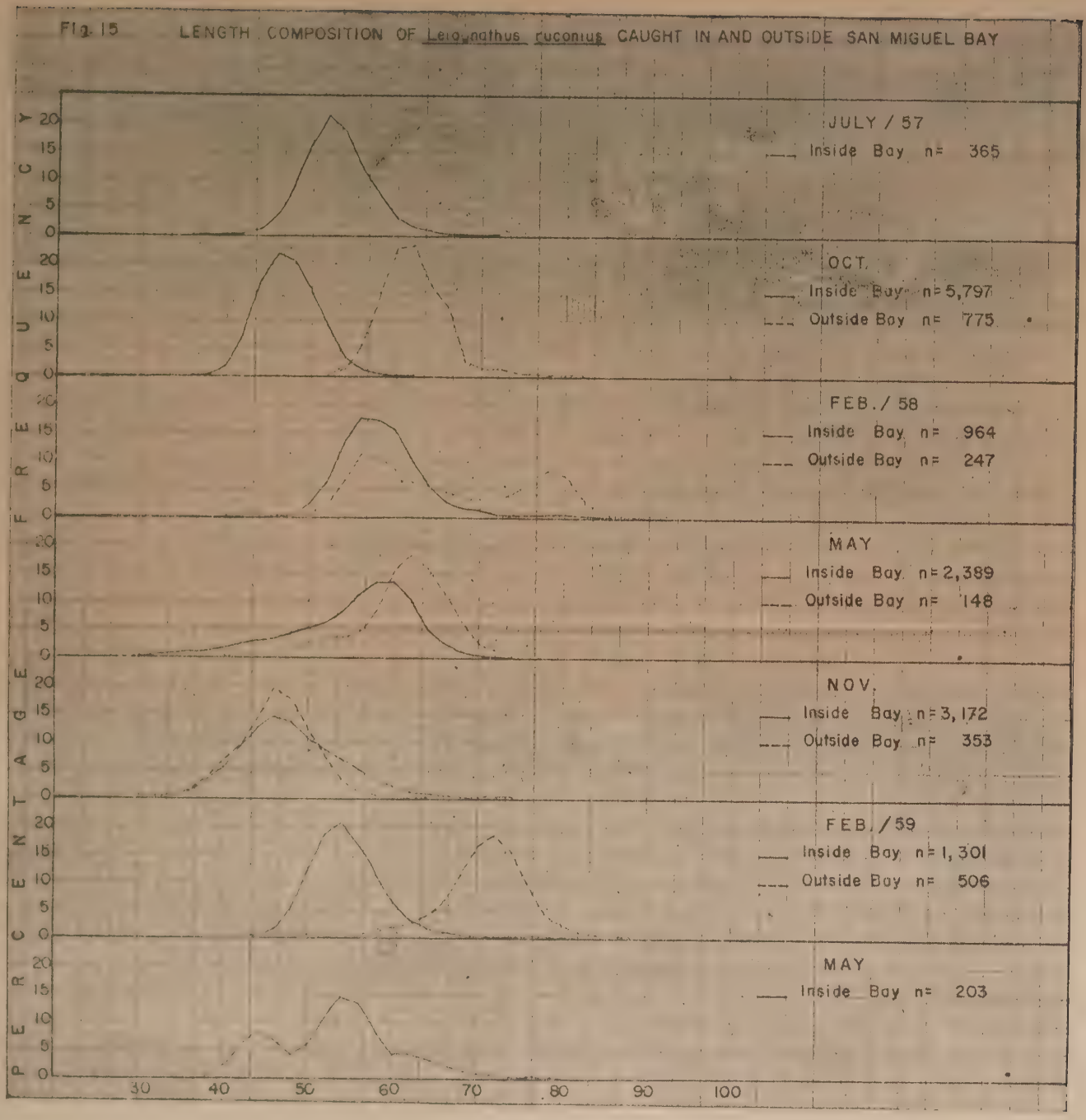


Fig. 14 LENGTH COMPOSITION OF [illegible] CAUGHT IN AND OUTSIDE SAN MIGUEL BAY
PERCENTAGE FREQUENCY
JULY / 57
Inside Bay n= 755
Outside Bay n= 36
OCT
Inside Bay n=2,002
Outside Bay n= 417
FEB / 58
Inside Bay n=3,220
Outside Bay n=1,116
MAY
Inside Bay n=1,702
Outside Bay n=1,555
NOV.
Inside Bay n=3,152
Outside Bay n= 327
FEB./ 59
Inside Bay n= 621
Outside Bay n= 996
MAY
Inside Bay n=3,330
Outside Bay n= 700
30 40 50 60 70 80 90 100 110 120 130

Fig. 15 LENGTH COMPOSITION OF *Leiognathus ruconius* CAUGHT IN AND OUTSIDE SAN MIGUEL BAY



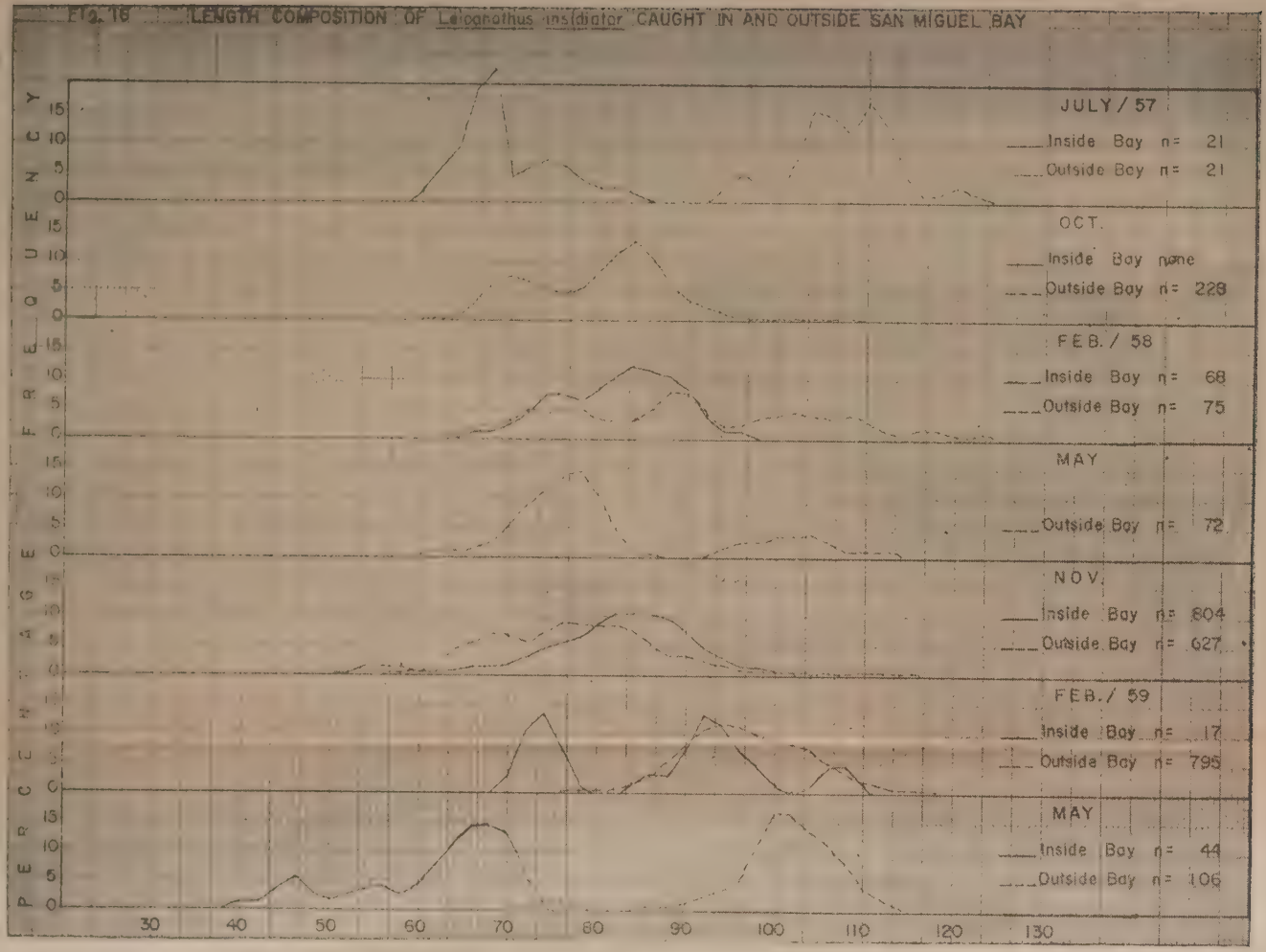


FIG. 16 LENGTH COMPOSITION OF Leiognathus insidiator CAUGHT IN AND OUTSIDE SAN MIGUEL BAY
PERCENTAGE FREQUENCY
JULY / 57
Inside Bay n= 21
Outside Bay n= 21
OCT.
Inside Bay none
Outside Bay n= 228
FEB. / 58
Inside Bay n= 68
Outside Bay n= 75
MAY
Outside Bay n= 72
NOV.
Inside Bay n= 804
Outside Bay n= 627
FEB. / 59
Inside Bay n= 17
Outside Bay n= 795
MAY
Inside Bay n= 44
Outside Bay n= 106
0
5
10
15
30
40
50
60
70
80
90
100
110
120
130

TABLE 10.—*Number of specimens caught in the baby trawl operation with a standard net of ¾ inch (stretched mesh) on the cod end (30 minutes' dragging time)*

Month	No. of hauls	Average total number of all specimens	*L. splendens*	*L. ruconius*	*L. bindus*	*L. insidiator*	*L. daura*	*L. blochii*	*L. lineolatus*	*L. equulus*	*Gazza minuta*	*Gazza achlamys*	Average total of slipmouths caught
1957 April	25	405	144	92	38	2	25	1	1	--	--	-------	303
May	8	435	108	138	28	3	25	--	19	--	--	-------	321
June	13	604	212	187	63	7	20	0	9	--	--	-------	498
July	24	1,321	757	247	4	6	38	5	16	--	--	-------	1,073
August	20	720	244	333	3	9	32	3	3	--	2	-------	629
September	26	1,032	246	522	21	39	45	5	5	0	2	-------	885
October	17	639	329	150	18	32	8	2	18	--	0	-------	557
November	24	2,113	988	778	95	64	11	6	15	--	5	-------	1,962
December	17	756	288	297	16	32	1	6	5	--	1	-------	646
1958													
January	16	556	196	205	22	6	6	5	1	--	0	-------	441
February	22	839	310	339	17	13	31	9	0	--	0	-------	719
March	31	355	94	93	19	4	48	3	0	--	0	-------	261
April	33	614	195	63	54	3	69	3	8	--	0	-------	399
May	30	650	399	93	44	3	15	1	19	0	--	-------	574
June	27	768	477	80	23	4	31	4	23	6	0	-------	642
July	30	859	508	130	15	9	26	7	21	0	1	-------	717
August	30	535	214	80	16	15	20	3	21	0	1	-------	370
September	11	3,301	1,974	717	29	28	43	17	36	--	11	6	2,861
October	30	398	189	85	3	4	47	8	5	--	2	0	343

numbers. This fishery is available to the otter trawl, the baby trawl, the fish corral, and occasionally to the "basnig" or bagnet. In spite of such versatility, there appears to be no danger of depletion, at least for the present, due to the fact that spawners have never been caught by the different gears in Manila Bay as well as in San Miguel Bay. It is presumed, therefore, that the mature fish go out of the Bay into the deeper waters to spawn and, therefore, are non-available to the fishery and are naturally protected since fishing vessels seldom fish in those places. Fishes which once have left the bay do not return into the bay anymore.

All year round, slipmouths are available in the different fishing grounds as each species has a different time of entering the fishing ground and leaving for deeper waters to breed. One species or age group is therefore replaced by another so that a new group is always available to the various fisheries.

These fish are sold in fresh state to consumers or to "patis" (fish sauce) makers thus supplying material for this growing industry. A small portion of the catch is salted and dried.

SUMMARY

1. In the course of this study, fifteen (15) species of *Leiognathus* and two species of *Gazza* were found, from which the presence of all species previously reported in Philippine waters was confirmed. *L. smithursti* (Rams. and Ogilby) previously unknown in Philippine waters, was found in San Miguel Bay. In addition, a new identification key is given because of several controversial views given in previous keys. Most of the species were observed to be present in Manila Bay and San Miguel Bay. *Leiognathus daura*, *L. lineolatus*, and *L. berbis* were found only in Manila Bay samples, while *L. dussumieri*, *L. smithursti* and *L. fasciatus* were observed only in San Miguel Bay samples.

2. A total of 920 catch samples of some 985,000 slipmouth specimens taken from controversial fishing gears, namely commercial otter trawl, baby trawl, and fish corral were examined. Investigations were carried out in Manila Bay and San Miguel Bay.

3. The fish corral fishery of Navotas, Manila Bay, depends entirely on slipmouth stocks, while the otter trawl fishery utilizes mainly other fish stocks. Since the baby trawls operate in

the same area where fish corrals are located, it is not surprising that this gear also depends on slipmouth stocks.

4. In the fish corral samples, *Leiognathus splendens* was dominant in all months while all other slipmouth species occurred much less frequently. Most likely, there exists a difference in the behaviour of different species to enter fish corrals as shown by *L. ruconius* and *L. daura* which were found to be abundant in the fishing area but were never found in considerable quantities in the fish corral. Instead, they are more numerous in the baby trawl catches.

5. The dominant species in the baby trawl catches were *L. splendens* and *L. ruconius*. No conclusion can yet be made on a characteristic yearly cycle in the abundance of the different stocks in the shallower parts of Manila Bay.

6. Fluctuations in the accessibility of fish stocks being formed by single species cannot be concluded from the Philippine catch statistics since the catch as listed is composed of too many species, sorting of which is practically impossible in a commercial fishing operation. Extensive research work is therefore, necessary to recognize the presence of wide fluctuations in the catch.

7. In the otter trawl fishery, the collected biological materials reveal that each of the abundant species, *L. bindus*, *L. splendens*, *L. ruconius*, and *L. insidiator* had a period of main abundance in the catches.

8. The trawl fishery very likely depends on stocks of slipmouth which are replaced by other species from time to time This happens in a rhythm which may correspond with that of a biological year but may also last longer or may be of a more accidental character.

9. *Leiognathus splendens* is utilized by different fishing gears according to its age groups. The younger age group, ranging from 25 to 45 mm. in length, is utilized by the fish corrals and baby trawls while the older group ranging from 45 to 90 mm. by the otter trawl fishery.

10. The yearly length increase of *L. splendens* was found to be about 50 mm. A similar growth rate was found for some of the other species.

11. *Leiognathus bindus* is a species with a distinct seasonal character. It has its main abundance about February to August in the deeper parts of the bay. The smaller age group is found from March to June in the shallower parts. This species is

normally more abundant in the deeper parts of the bay throughout the whole research period.

12. *Leiognathus insidiator* can also be considered a species of the deeper waters. A younger year class was occasionally observed in some research months in the baby trawl area.

13. From April to September 1957, *L. ruconius* was much more abundant in the baby trawl area than in the deeper waters. From October to December 1957, however, suddenly it was the most abundant species in the otter trawl fishery. The length composition of specimens caught in otter trawls varies only a little.

14. *Leiognathus daura* was mainly caught by the baby trawls.

15. *Leiognathus lineolatus* was caught in both sampling operations in nearly equal proportions although it could not reach any larger share on the total catch of slipmouths than about 6 per cent during the period of research.

16. *Leiognathus equulus* is a fish of the deeper waters. *Gazza minuta* was scarcely represented in the catches of both sampling gears.

17. The collected materials indicate that the younger fishes widely prefer to stay in the shallower area. Several months after their first appearance, they normally leave this area, having considerably grown in the meanwhile, and migrate to the deeper parts of the bay.

18. In San Miguel Bay, the more abundant species, *L. splendens, L. bindus* and *L. ruconius* show that the larger length groups were found only outside the bay.

19. Based on the average number of specimen of single species caught by baby trawl for 30 minutes dragging time with a standard net of ¾ inch in the cod end, the absolute abundance of slipmouths in the coastal parts of Manila Bay was determined. *L. splendens* was the most abundant; *L. ruconius* came next and *L. bindus* ranked third. The share of other species was insignificant.

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ILLUSTRATIONS

PLATE 1. Different species of Leiognathus found in Manila Bay.
2. Gazza and Leiognathus species found in Manila Bay.

TEXT FIGURES

Station Map—Manila Bay

FIG. 1. Stations covered by commercial & baby trawl operations in Manila Bay. 1 to 43—Commercial trawl; I a, b, B; II c, d, D; III e, f, F; IV g, h, H; V j, k, K; VI l, m, M—Baby trawl.
2. Share of Leiognathidae by weight on the total catch of different gears in %—Manila Bay.
3. Seasonal changes in the catch composition of slipmouths in commercial otter trawl.
4. Length composition of *leiognathus splendens*—Manila Bay.
5. Length composition of *leiognathus splendens* caught with different mesh sizes in Manila Bay—Baby trawl operation.
6. Length composition of *leiognathus bindus*—Manila Bay.
7. Length composition of *leiognathus insidiator*—Manila Bay.
8. Length composition of *leiognathus ruconius*—Manila Bay.
9. Length composition of *leiognathus daura*—Manila Bay.
10. Length composition of *leiognathus lineolatus*—Manila Bay.
11. Length composition of other *leiognathus* species with irregular occurrence the year through 1957–1958 in Manila Bay.
12. San Miguel Bay and adjacent waters.
13. Length composition of *leiognathus splendens* caught in and outside San Miguel Bay.
14. Length composition of *leiognathus bindus* caught in and outside San Miguel Bay.
15. Length composition of *leiognathus ruconius* caught in and outside San Miguel Bay.
16. Length composition of *leiognathus insidiator* caught in and outside San Miguel Bay.

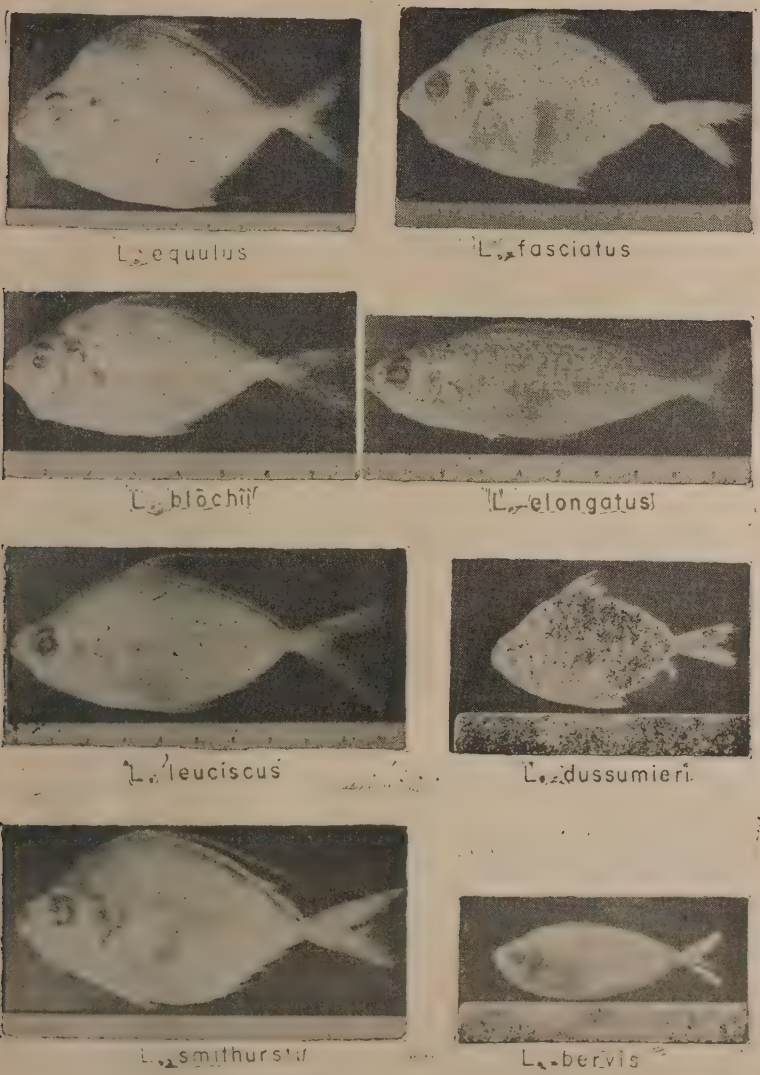
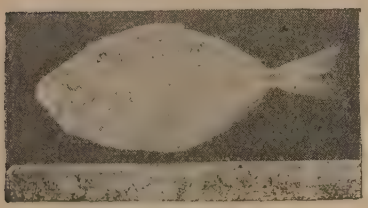
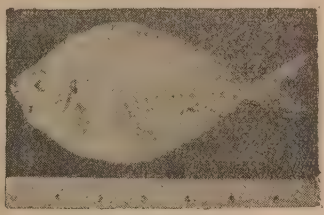
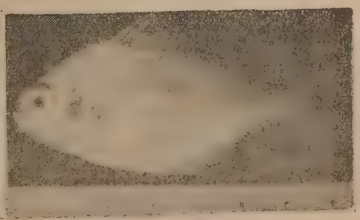


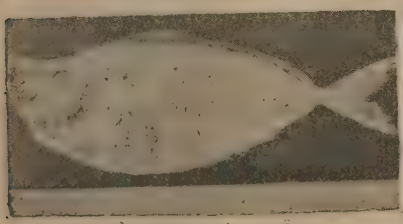
PLATE 1

Different species of Leiognathus found in Manila Bay









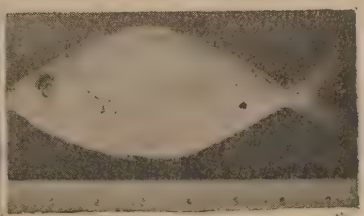


PLATE 2

Gazza and Leiognathus species found in Manila Bay

OCEANOGRAPHIC RESEARCH IN THE PHILIPPINES[1]

By Inocencio A. Ronquillo
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ABSTRACT

The Philippine Archipelago, being surrounded by bodies of water of different depths, has been the object of visits by several foreign research vessels since 1846. All the studies made of Philippine waters were mostly aimed to investigate the extent of the Philippine Deep.

The U. S. Fish and Wildlife Service through the Philippine Fishery Program, with the use of the *S. F. Baird*, focused its investigations on coastal and inshore areas from 1947 to 1950, forming the basis of future oceanographic research in the islands. Upon the termination of the Program and with the turn-over of the *David Starr Jordan* to the Philippine Bureau of Fisheries, a well-planned investigation of bays and gulfs was carried out in Manila Bay and Lingayen Gulf.

In November, 1956, the Section of Hydrology and Fisheries Biology started the marine fishery biological research programme with the help of the FAO technical assistance officer on marine biology. The programme was divided into two phases—fishery biology and oceanography. Again the oceanographic activities were confined to Manila Bay and approaches which, however, were later on extended to San Miguel Bay in Southern Luzon.

Oceanographic investigations include studies on hydrology, plankton, benthos and primary productivity. From the different hydrographic stations that were occupied, temperature, salinity, oxygen, pH, phosphate and transparency data were collected.

The study on the distribution of plankton was made to show its relation to fish stock abundance in the bay. It was found out that the phytoplankton materials were more abundant in the shallower parts of the Bay while the zooplankton organisms

[1] Submitted at the First International Oceanographic Congress sponsored by the American Association for the Advancement of Science in collaboration with the International Advisory Committee on Marine Science of UNESCO and the Special Committee on Oceanic Research of the ICSU at New York, Aug. 31-Sept. 12, 1959.

were more abundant in the deeper portions. It was noted that blooms of copepods follow a rich phytoplankton bloom and this could be correlated with the better fish catches in subsequent months.

Benthos studies, on the other hand, determine the density of animal life in the sea bottom which is found to have direct bearing on the abundance of bottom-feeding fishes.

Studies on primary productivity by means of the radioactive C–14 technique were also undertaken in connection with the research programme.

EARLIER WORK

The first Danish *Galathea* Expedition in 1845–1847 visited and made collections in Manila, Dinagat, and Surigao in 1846. However, the H.M.S. *Challenger* Deep-Sea Expedition in 1875 collected more data on the Philippine deep seas and animal life due to improved equipment. Since then almost all world-wide oceanographic expeditions have visited the Philippine seas. Among the most noteworthy is the *Albatross* Philippine Expedition of 1907–1909 which made the most extensive investigation of sea life in the islands. This expedition was sponsored by the then U. S. Bureau of Fisheries.

Other oceanographic investigations are those of the German survey vessel *Planet* (1907–1912) and cruiser *Emden* (1927); the Danish research vessel *Dana* II (1929); the Dutch *Snellius* Expedition (1929); the U. S. Naval vessel *Cape Johnson* (1945); and the Danish Deep-Sea *Galathea* Expedition (1951–1952) which trawled the deepest part of the Philippine trench. The Philippine Deep, once the world's deepest, attracted the attention of most research vessels of the expeditions.

The studies of Philippine waters were mostly confined to the investigation of the extent of the Philippine Deep. It was not until 1947 that an intensive oceanographic exploration of the Philippines and adjacent seas was undertaken on a wide coverage.

POSTWAR ACTIVITIES IN OCEANOGRAPHY AND FISHERIES

Through the operation of the "*S. F. Baird*" of the Philippine Fishery Program of the U. S. Fish and Wildlife Service during the period from 1947 to 1950, more than 1,100 hydrographic stations spreading over an area of more than 800,000 square miles were occupied. Observations made at each station in-

cluded temperature, salinity, dissolved oxygen, phosphate, nitrate, hydrogen ion, and silicate. The observations extended generally to the depth of 2,000 meters and, in some cases, to 4,000 meters.

The waters surveyed included the Celebes Sea, the Sulu Sea, all of the smaller seas of the Philippines, the nearby waters of the South China Sea, and the waters of the Pacific east of the Philippines now known as the Philippine Sea to a distance of about 300 miles from the shore. Most of the areas were surveyed twice, once during the northeast monsoon and once during the southwest monsoon. These investigations made the Philippine waters one of the most surveyed areas in the world. As far as it is known, only a small part of the collected data has been processed and published.

This contribution of the U. S. Fish and Wildlife Service to Philippine oceanography served not only as a foundation of later oceanographic research in the country but also as an example in the extension of the work to coastal inshore areas. The training it provided to Philippine workers who were with the survey ship is invaluable.

Following the termination of the Philippine Fishery Program, the 30 ton *David Starr Jordan,* a small but sturdy vessel, together with important oceanographic equipment was turned over to the Philippine Bureau of Fisheries. A program of investigation of bays and gulfs was undertaken later by the Bureau with the use of this research vessel and equipment. Monthly surveys of Manila Bay and Lingayen Gulf were undertaken to determine the cycles of oceanographic conditions and their relation to wind, weather and season. Exploratory surveys were also conducted in Batangas Bay, Balayan Bay and Malampaya Sound.

Of the areas surveyed since the work commenced in February, 1951, Manila Bay in Luzon Island has been the most comprehensively studied. The area was visited every month for one year, occupying a total of fifteen stations whenever weather conditions permitted. A total of 3,115 measurements of physical and chemical properties of the waters of Manila Bay was taken during the year of survey. A report on the oceanography of Manila Bay describing the inter-relationship between the physical and chemical parameters was published by Megia *et al.* in 1953. The data on Lingayen Gulf have already been processed and are contained in another paper.

PROGRAMMES OF MARINE FISHERIES RESEARCH, 1956–1959

A very important work of the Bureau of Fisheries was launched at the Section of Hydrology and Fisheries Biology of the Division of Fisheries Research in 1956. This is the marine fisheries research program which was initiated and carried out into fruitful operation by Dr. K. F. Tiews of the Institüt für Küsten und Binnenfishcherei of Hamburg when he was detailed as FAO technical assistance officer on marine biology in Manila under the United Nations Expanded Technical Assistance Programme.

All the activities were conducted at the Dagat-dagatan Salt-water Fishery Research Station at Malabon, Rizal where more than 50 technical men and women assistants underwent training in the rudiments of fishery biology.

The work of the Section is broadly divided into two categories—fishery biology and oceanography. The studies relating to fishery biology deal with the fish stocks, migrations, distributions, life histories and other aspects of fish life which have bearing on fishery problems. The major pelagic and demersal fisheries of Manila Bay as anchovies, roundscads, chub mackerels, slipmouth, threadfin breams, lizard fishes and shrimps were investigated in detail in an attempt to understand the factors involved in their biology, abundance and availability.

Oceanographic activities were confined to Manila Bay and approaches, where a line of five stations starting from the head of the bay to the entrance was occupied every month. Two stations are within the approaches of the Bay and three are inside the Bay.

Hydrographic data are collected monthly on special oceanographic trips in connection with special research on water movement, the distribution of plankton, fish eggs and larvæ, bottom ecology and primary production.

In addition, a team of 3 assistants goes with commercial otter trawlers in Manila Bay every two weeks to measure fishes on board and collect samples for study at the shore laboratory.

Likewise, at each station of net hauling, water temperature readings and water samples for nutrients and salinity are taken from the surface and bottom water layers. Further, an experimental small trawl has been operated in Manila Bay for at least four days a week since April, 1957.

San Miguel Bay in Southern Luzon, on the Pacific side, was included in this study in September, 1957, and similarly sur-

veyed every three months thereafter, for comparison of the conditions there with Manila Bay.

From 1,258 hydrographic stations in Manila Bay, data for 2,085 temperature readings, 2,160 salinity, 412 oxygen, 76 pH, 401 phosphates and 174 transparency determinations were collected.

The data are being compiled presently and will be used for the interpretation of biological findings. They will be published as raw data in mimeographed form. The results taken in connection with the biological investigations will be published as further observations on the hydrography of Manila Bay, 1957–1959.

PRELIMINARY RESULTS ON OCEANOGRAPHY OF MANILA BAY AND SAN MIGUEL BAY, 1957–59

Hydrography.—Comparisons of the present observations with those made in 1951–1952 show a temperature difference of 2.43°C at the surface and 1.52°C at the bottom. There was a difference in the surface salinity of 6.99‰ and 0.77‰ at the bottom. Differences were also found in the oxygen and phosphate content of the surface and bottom waters.

These observed deviations, especially of the temperature changes of Manila Bay, indicate the necessity of continued researches along this field as it may help explain the fluctuations on the movement and availability of fish stocks in Manila Bay.

Although temperature readings and salinity determination which were made during the field trips to San Miguel Bay tally in a general way with those made in Manila Bay, yet they are insufficient to allow a direct comparison.

Plankton Ecology.—The investigations on the distribution of plankton are made with special regard to the fluctuations in the availability of food organisms to the fish stocks and the distribution of fish eggs and fish larvæ in and near Manila Bay.

The plankton collection was started in April, 1957, after the arrival of plankton nets from the FAO Headquarters, Rome. During the monthly field trips in Manila Bay, three vertical hauls with a Hensen egg net and a 10-minute horizontal drag with a larval ring trawl were made at each of the five standard stations occupied. Since then, 274 vertical and 90 horizontal samples have been taken. Of these, 268 were roughly sorted and components determined. Similar study was extended to the San Miguel Bay area and samples were systematically taken

at three fixed stations, which were occupied once every three months.

Analysis of samples by animal type and number was made from Stations B in Manila Bay and D outside the Bay for comparison of catches during the first year and is being continued to the present. Samples of plankton materials were taken to England for verification by the assistant on planktonology who is now undergoing training there under the Colombo Plan.

Based on 104 vertical hauls made at Stations A, B and C from April, 1957, to March, 1958, it has been observed that catches were highest in the center of the Bay at Station B, followed by Station A, indicating a greater abundance of plankton inside the bay than outside by a ratio of 2 to 1.

Based on the average of 104 plankton tows made at stations A, B and C whose depths correspond to the average depth of the Manila Bay of 27 meters, it has been calculated that the average standing crop of plankton in Manila Bay is 49,000 metric tons. This represents the minimum value inasmuch as the cod end used in the Hensen egg net was nylon parachute silk instead of regular No. 3 bolting cloth and this proved to be very unsatisfactory. Checked with this material in the latter part of 1958, it was observed that an average increase of catches up to 167 per cent was made indicating that the efficiency of the nylon net was only 38 per cent.

Considering this error, it may be estimated that the plankton standing crop of Manila Bay amounts to at least 157,000 metric tons equivalent to 1,160 kg. per hectare. This estimate is still low when we consider the observed large changes in the catch composition because the biological turnover has not been included and since most of the microplankton and many of the larger forms shall have escaped the net. Tiews, (1958).

It was observed that there are more phytoplankton in the shallower part of the bay, and that zooplankton is more abundant inside the bay.

Plankton catches inside the bay were maximal in June and above average in October and December, 1957, and March, 1958. Significant bloom of *Chaetoceros,* filamentous algæ, *Thalassiothrix* and *Rhizosolenia* contributed to this high value observed from Station B. The following organisms were also found to be more abundant than in other months: *Richelia, Hemiaulus, Nitzschia, Oscillatoria,* larvæ of sea urchin, *Ceratium tripos, Ditylum, Eucampia, Ceratium fusus,* pelecypods and *Vorticella.*

It is not as yet possible to detect the real correlation between the plankton abundance and abundance of fish stocks in the bay due to lack of accuracy in the fish catch statistics. However, it seems that the rich phytoplankton bloom of June, 1957, gave rise to the bloom of copepods, an important food item which was observed abundant in the following months; likewise, it was observed that the fish catches then were generally better than in the previous months.

Benthos.—A benthos survey with a Petersen bottom grab was initiated in Manila Bay to determine the density of animal life in the sea bottom upon receipt of two grabs of 1/10th square meter size from FAO Headquarters, Rome. Research on the benthos biomass in tropical waters is rare and this study may therefore fill an important gap in the knowledge on the production biology of tropical waters.

In September, 1957, nine stations were selected from a series of 67 stations occupied in the previous month. These nine stations were occupied monthly until June, 1958, when the second bottom grab was lost. Three bottom samples were taken from each station. In this survey, 333 bottom samples were taken, sieved, and roughly sorted and analyzed. Similar research was extended to San Miguel Bay where 32 different stations were occupied in September, 1957, February and May, 1958, and from which 68 samples were analyzed. The following observations were made:

There was a great difference in the benthos biomass of Manila Bay and San Miguel Bay. The average of 260 Manila Bay samples from 9 standard stations was only 0.74 gram per 0.1 square meter, whereas it was 7.96 grams from 57 San Miguel Bay samples from 15 stations. In the average, 3.5 animals were taken per 0.1 square meter in Manila Bay as compared to 5.8 in San Miguel Bay. Most of the 917 animals caught in Manila Bay were small errantian polychaetes, small macrurans, sedentary polychaetes, brachyurans, and others.

The composition of bottom samples from San Miguel Bay is quite different. More than one half of the 330 animals taken were sedentary polychaetes, the others were errantian polychaetes, ophiuroids, brachyurans, nemerteans, macrurans, and others.

The different composition of the benthos fauna in both areas is reflected in the difference which was observed in the average weight of organisms caught, namely, 0.21 gram in Manila Bay and 1.37 grams in San Miguel Bay

In both areas, the nature of the bottom was classified according to their substratum of grayish mud, greenish mud, sandy mud and sand. In Manila Bay, grayish mud was most productive followed by sandy substratum and greenish mud; sandy mud was least productive. In San Miguel Bay, the greenish mud zone in the center of the Bay was most productive followed by sandy mud and grayish mud. Sandy substratum was least productive.

It is believed that the higher productivity of benthos biomass in San Miguel Bay has direct relationship to the more abundant catch of shrimps and flatfishes there than in Manila Bay. It has been demonstrated that shrimps feed on bottom organisms. Investigations on the food habits of flatfishes have been initiated to determine the food in the area.

Although Manila Bay with an area of 1,350 sq. km. is 2.6 times larger than San Miguel Bay (520 sq. km.), the standing crop of benthos biomass of the latter is 4 times greater, namely, (40,000 metric tons). In short, the standing crop of Manila Bay is 74.1 kg. ha., while that of San Miguel Bay is 795.7 kg./ha.

In both areas there was no evidence that trawl fishing influences the bottom fauna as believed by certain fishermen. Benthos organisms were found in similar densities in areas in which no trawling is done.

Primary Production.—In March, 1958, research to determine the primary productivity of Manila Bay by means of the radioactive C–14 technique was initiated thru the kind cooperation of Dr. Maxwell Doty of the University of Hawaii who was then studying the productivity of marine waters in this part of the Pacific. This study will give indications of the relative fertility of different areas which may help in the proper development of the fish resources of areas not yet adequately developed.

Since then, 69 samples together with 138 control samples in Manila Bay were treated by standard procedure; 33 samples plus 66 control samples from San Miguel Bay were similarly treated. All dried materials were sent to the University of Hawaii for radiation analyses. The data from these analyses will be correlated with other researches on plankton abundance, hydrography, and availability of fishes.

Preliminary results obtained indicate that the carbon uptake of phytoplankton is astonishingly high in the bay waters.

Productivity rates were generally found to be higher in the shallow coastal areas than in the deeper off-shore parts of the bay. This high value is more or less confirmed by the average fish catch of Manila Bay based on the total catch figure of 8,381 metric tons as given in the Fishery Statistics which is about 62 kg. per hectare in 1956.

Based on the findings of a small experimental trawl boat operated in the shallower areas of Manila Bay, the average catch per year is estimated to be at least 10 metric tons for one small trawler. With 1,500 small trawlers operating in the Bay, their total catch is roughly estimated at 15,000 metric tons per annum, excluding the catch of bagnetters, otter trawlers, and fish corrals. It is, therefore, calculated that the total fish production of Manila Bay amounted to at least 20,000 to 25,000 metric tons in 1957.

Apparently, Manila Bay is one of the most productive fishing areas of the world, being comparable to the best fishing ground of Europe.

The general conception that tropical waters are poor in fisheries productivity can obviously not be applied to the Philippine waters which have a higher productivity than, for example, the North Sea, one of the richest fishing grounds of the world, yet only with an average productivity of 26.4 kilograms per hectare in 1948. Although fishing areas like the Manila Bay are rare in the Philippine Archipelago, the Bay gives an excellent example as to the extent in which such a fishing area can be developed if modern gear like the small trawl, otter trawl, and bagnet are used for the exploitation of the resources. All these studies are being continued to give more reliable results.

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